MICOM NAC

AD A115776

Manufacturing Methods Report
MICOM MM&T Project R793438

# DELIDDING AND RESEALING HYBRID MICROELECTRONIC PACKAGES

Contract No. DAAH01-80-C-0435

Final Report

Wyatt F. Luce
Westinghouse Electric Corporation
Baltimore, Maryland 21203

May 1982

Approved for Public Release - Distribution Unlimited

PREPARED FOR

**MICOM**
U.S. ARMY MISSILE COMMAND,
REDSTONE ARSENAL, AL 35898

**NAC**
U.S. NAVAL AVIONICS CENTER
INDIANAPOLIS, INDIANA 46218

# NOTICES

## DISCLAIMERS

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government endorsement or approval of commercial products or services referenced herein.

## DISPOSITION

Destroy this report when it is no longer needed. Do not return it to the originator.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

# REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

| | | |
|---|---|---|
| 1. REPORT NUMBER<br>MM&T Project No. R793438 | 2. GOVT ACCESSION NO.<br>AD-A115 776 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>DELIDDING AND RESEALING HYBRID MICROELECTRONIC PACKAGES | | 5. TYPE OF REPORT & PERIOD COVERED<br>FINAL<br>15 FEB 80 - 15 DEC 81 |
| | | 6. PERFORMING ORG. REPORT NUMBER<br>55744 - 5/82 |
| 7. AUTHOR(s)<br>Wyatt F. Luce | | 8. CONTRACT OR GRANT NUMBER(s)<br>DAAH01-80-C-0435 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Westinghouse Defense & Electronic Systems Center<br>Baltimore, Maryland 21203 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U.S Army Missile Command<br>Redstone Arsenal, Alabama 35898 | U.S. Naval Avionics Ctr.<br>Indianapolis, Indiana 46218 | 12. REPORT DATE<br>May 1982 |
| | | 13. NUMBER OF PAGES<br>81 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release - Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Abridged version presented at 1982 Electronic Components Conference

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

| | |
|---|---|
| Hybrid Microelectronic Package | Hermetic Sealing |
| Planar-Lead Butterfly Package | Delidding |
| Bottom-Pin Bathtub Package | Resealing |
| Resistance Seam Welding | Mil- M -38510 |
| Sharp Precision SP112 | Qualification Testing |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this single phase MM&T contract was to develop the manufacturing technology necessary for the precision removal (delidding) and replacement (resealing) of covers on hermetically sealed hybrid microelectronic packages. The equipment and processes developed provide a rework technique which does not degrade the reliability of the package of the enclosed circuitry. A qualification test was conducted on 88 functional hybrid packages, with excellent results. A petition will be filed, accompanied by this report, requesting Mil-M-38510 be amended to allow this rework method.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE



UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

## PREFACE

This Final Report was prepared by the Westinghouse Electric Company, Defense and Electronic System Center, Baltimore, Maryland, in fulfillment of Contract DAAH01-80-C-0435, "Delidding and Resealing Hybrid Microelectronic Packages." The work was sponsored jointly by the Army Missile Command, Redstone Arsenal, Alabama and the Naval Avionics Center, Indianapolis, Indiana. Messers. Thomas Henegar, Milton A. Sulkowski, and Paul Wanko served successively as Technical Monitor for the Army. Mr. Kent A. Harmison served throughout as the Navy Technical Monitor.

This report covers work conducted from February, 1980 through December, 1981. The Westinghouse Principal Investigator was Mr. Wyatt F. Luce, Manufacturing Engineer. Mr. Louis A. Razzetti, Manager, Hybrid Manufacturing Engineering, served as the Westinghouse Program Manager initially, and was succeeded by Mr. Luce. Valuable technical assistance and direction was provided by Mr. Gene A. DiGennaro, Senior Manufacturing Engineer, who served as the Westinghouse Engineering Manager.

The author wishes to thank Mrs. Margaret C. Howard, Supervisor, Hybrid Prototype Laboratory, for the invaluable assistance she and her technicians provided during the development portion of this effort. Many thanks also go to Mr. James Victor of Sharp Precision, Thousand Oaks, California for his continuous cooperation and technical contributions. Additionally, Westinghouse would like to thank the numerous participants in the industry survey; their inputs helped tremendously in establishing the direction of this effort, and their support will help ensure widespread implementation of the technology developed.

TABLE OF CONTENTS

# I. INTRODUCTION

## A. GENERAL

Rework is a vital part of manufacturing hybrid microelectronic packages. As Military hybrids grow in size and complexity, the need for effective rework increases. Further, once a package has been sealed, almost all of the necessary labor and materials have been invested. If the hybrid fails at this point, scrapping is an expensive and undesirable choice. Removing the lid, and remounting the substrate in a new package is possible, but requires many extra handling steps and several thermal excursions which degrade the reliability of the hybrid.

Delidding and resealing, on the other hand, offers the capability to repair a circuit with minimum expense and degradation. Simply stated, delidding and resealing involves removing the lid from a sealed hybrid package, repairing the circuit, and hermetically resealing a new lid onto the original package. In addition to reducing the time required to complete a rework, delidding and resealing reduces the associated labor and materials costs, and does not require additional thermal excursions.

## B. OBJECTIVE

A number of manufacturers had at least a rudimentary technique for delidding and resealing hybrids. Few, if any were really suited to volume production use. The objective of this effort was to develop the equipment and processes necessary for effectively delidding and resealing hybrid microelectronic packages. The techniques developed were to apply to the most commonly used Military hybrid packages, and be easily implemented throughout the industry.

This objective was met by achieving four goals: the technique had to be reliable, fast, safe, and production oriented. First, to be reliable, the technique had to ensure predictable, repeatable results. The lid must be removed cleanly; the enclosed circuit must not be damaged or contaminated such as by being exposed to heat, particles, static electricity, excessive vibration, or cutting fluids. Further, the package header must not be damaged; the glass to metal seals must remain hermetic, and the seal flange must allow easy rewelding with high leak test yield.

Second, the equipment had to remove lids from packages fast. It should also be easy to set up and use, and to adjust as needed; controls should be few and simple. Eliminating the need to dress the flange after the lid is removed not only saved time, it avoided the potential damage resulting from this manual operation.

Operator safety must not be endangered at any time. Use of sharp knives in manual operations was undesirable. Moving parts, especially those designed for cutting, should be concealed.

Machining particles should not be allowed to fly towards the operator's face. One way to maximize operator safety was to keep their hands away from the machine through as much of the operation as possible.

Fourth, being production oriented meant more than just being fast. Achieving a high volume throughput required a fast process; keeping up the throughput required dependable equipment. Low equipment downtime and maintenance requirements were essential. Minimizing the amount of labor needed and lowering the requisite skill level helped to reduce expenses. Finally, in order to take advantage of the technique at all, the equipment had to be affordable to buy, install, and put into production.

## C. APPROACH

The approach to this important problem is evident from the four major program elements: industry survey, equipment and process development, qualification testing, and implementation.

First, an industry survey was conducted in order to gather baseline data on package usage and trends, delidding and resealing techniques being used and their cost and reliability impact, and industry recommendations for delidding and resealing. A mailed questionnaire, followed by telephone interviews and visits to selected companies, provided extensive state-of-the-art information on which to build. This information also served as the basis for selecting the package configurations which offered the greatest potential savings from delidding and resealing. With the package selection made, the best delidding method for that package could be selected, and the most promising variation identified and developed.

Having selected the package and equipment, the necessary equipment development, redesigning, and refinement was undertaken. Along with establishing the equipment, the proper technique for using it had to be developed, along with all the necessary process parameters. Optimum parameters and operating tolerances were empirically established.

Proving that the equipment and process were truly effective was the purpose of a rigorous qualification test. Full Mil-Std-883 Class B hybrid screening was conducted on 88 functional hybrids, most of which were delidded and resealed using the methods developed. Electrical, fine and gross leak, and particle impact noise detection (PIND) tests were highlighted, although a full range of mechanical and environmental tests were performed.

Based on the excellent qualification test results, the technique developed was implemented on all applicable Westinghouse product. Other hybrid manufacturers are already implementing this technique, by waiver to Mil-M-38510. The key to widespread implementation at this point is the successful petitioning for inclusion of this technique in Mil-M-38510 as an approved rework method.

## II. SUMMARY

### A.. SURVEY HIGHLIGHTS

Response to the industry survey questionnaire was excellent, with 57 companies providing useful information on Military hybrids 3/4 inch square or larger. The respondents manufacture 800,000 hybrids annually, with a value of over $240 million. Welded butterfly packages were the most commonly used style, with over 40% of the total; welded bathtub packages ranked second with almost 24%. Welded packages in general accounted for over 80% of the total. Packages which were approximately 1" x 1" accounted for more than 66% of the response. Soldering and ceramic packages are both on the way out; growing use of larger packages is in.

Delidding of welded packages by end milling was the most common by virtue of more companies utilizing it, but precision sawing was used on more packages, and was the most often recommended method. Welded packages could typically be resealed two times, without seriously affecting yields. Soldered package delidding was typically done using a knife, soldering iron, hot plate, or a combination of these; reseal was usually only done once. Cost savings from delidding and resealing was reported to be $2.5 million already, but widespread implementation of a technique effective for two reseals was projected to save in excess of $10 million annually.

### B. SELECTION OF PACKAGE CONFIGURATION AND DELID METHOD

Survey data showed that 1" x 1" welded butterfly packages were the most commonly used configuration, but the trend was to larger packages. Also, larger packages have more glass seals, and a greater possibility for flatness tolerances to be a problem. Since a method developed for the larger package would apply to the smaller one, 1" x 2" welded butterfly packages were selected. Precision sawing promised to be more effective than end milling at removing lids without affecting the circuit and package, largely because of a newly introduced machine, the Sharp Precision SP110 Microcircuit Cover Remover. Industry recommendations favored the SP110, and initial investigation supported that choice as the best candidate.

### C. DEVELOPMENT EFFORT

The SP110 was brand new, and needed debugging and refinement in order to satisfy the goals outlined earlier. Most aspects of the machine's design were at least slightly modified; some major changes were made, also. These changes affected the table, clamp, motor, saw blade, and pneumatic plumbing in an effort to improve the equipment's performance and ease of adjustment, and to extend it's capability. The operating procedure was modified somewhat. Optimum process parameters and acceptable tolerances were established. Feasibility studies were also conducted on other package configurations, with favorable results.

## D. QUALIFICATION TEST PLAN AND CRITERIA

Verification that the delid/reseal technique was effective and reliable was obtained through a rigorous qualification test program. Eighty-eight functional hybrids were built, and 66 were delidded and resealed using the method developed. These hybrids were then subjected to fine and gross leak, electrical, and PIND tests, as well as numerous mechanical and environmental tests. Some packages were even subjected to moisture and corrosion resistance tests. These tests were conducted to Class B hybrid requirements, using Mil-Std-883 methods.

## E. QUALIFICATION TEST RESULTS

Both the delidded and resealed packages, and the control packages which had not been delidded, performed very well throughout the qualification testing. Virtually every test was passed with 100% yields. The only exception worth mention here is that PIND yields were 94% and 95%, respectively, for the delidded and the control groups. While this is not perfect, the two groups did perform essentially identically, and at a very high level. Overall, it was virtually impossible to tell a package that had been delidded and resealed from one that had not, merely by looking at it physically or by monitoring it's testing performance.

## F. CONCLUSIONS

Delidding and resealing is necessary for keeping down the cost of hybrid microelectronic packages. A delidding and resealing method was developed which would accommodate most of the hybrids being built for the Military market. The contractual objective and goals have been achieved. Qualification testing has shown the Westinghouse-modified SP110 to be effective, with no degradation observable after resealing using conventional welding techniques. Implementation at Westinghouse has already occurred, and other companies are anxious to utilize the technique, too. Availability of the modified SP110, which has been numbered the SP112, is improving.

The real limitation for widespread implementation and maximum cost savings is the fact that Mil-M-38510 prohibits delidding and resealing. Projections based on survey data show savings exceeding $10 million annually are possible. At the time of this report's issuance, Westinghouse will petition the Government to amend Mil-M-38510 to allow delidding and resealing as described herein.

## III. INDUSTRY SURVEY

### A. GENERAL

An important step at the outset of this contract effort was to collect information on existing industry delidding and resealing techniques. The most successful techniques were determined, along with the styles of packages each could accommodate. Data was also collected on the quantities used of each of the myriad of package styles used in the industry. Based on this data, the single most promising delidding technique was decided upon. The approach selected had to offer a high probability of success, and be as universally applicable as possible.

Towards this end, the Industry Survey covered the quantities of packages used, broken down by style, size, and sealing method. The methods used for delidding and resealing each configuration were also investigated, along with the problems encountered for each method. Yield, reliability, and cost impact of delid/reseal received special attention. Last, each survey recipient was asked to recommend the delid/reseal method they favored, even if it was not their present technique.

In order to maximize the benefit from this contract to the Military sector, the survey covered only those packages likely to need delidding and resealing. In particular, the survey was directed at hybrid packages 3/4 inch square and larger, and intended for Tri-Services applications. Data for smaller or commercial hybrids, including T-O cans, was not included in the data tallied later in this section.

### B. FORMAT

As the first phase of the data collection,a detailed questionnaire (Appendix A) was mailed to package manufacturers, hybrid circuit manufacturers, hybrid users, development laboratiories, and anyone else identified as being concerned with hybrid packaging. Well over 300 questionnaires were mailed to contacts at 158 companies, or independent divisions thereof. Whenever possible, personal contacts and acquaintances at each company were included in the mailings, in order to help ensure accurate and timely responses.

Despite this, many questionnaires were not returned. This was partially due to the length of the questionnaire, although most of the answers are simple and could be completed quickly. In many cases, entire pages of the questionnaire did not apply, and did not need to be completed. In order to emphasize this fact, and to encourage additional returns, a phone call follow up was initiated. The telephone interviews also served to clarify some particular answers, and to obtain data for questions left blank. A number of comapnies chose not to complete the questionnaire in writing, but provided most of the desired information over the phone.

The final phase of the Industry Survey was visiting ten companies who were most successful at delidding and resealing, had the most interesting approaches, or offered other valuable, relevant information. All of the most common welded and soldered package delidding and resealing techniques were observed. By witnessing these operations firsthand and dealing with the responsible people on a face to face basis, a tremendous amount of additional, pertinent information was obtained. Very few companies refused requests for personal visits. Most companies were very interested in the success of this contract, and thus, were friendly and helpful.

C. SURVEY RESPONSE

Overall, the Industry Survey response was excellent. Figure 1 depicts a breakdown of the overall survey response. Of the 158 companies (or independent divisions thereof) surveyed, 39 completed the questionnaire; 15 others provided partial information by mail or phone. These respones provided data on hybrids intended for Military applications. Three other responses provided useful data on commercial hybrids, such as for medical applications. (Medical systems typically have requirements comparable to or even exceeding those for Class B Military hybrids.) Thus, there were 57 useful responses, resulting in a 36% useful response rate. This is considered a good response to a technical questionnaire.

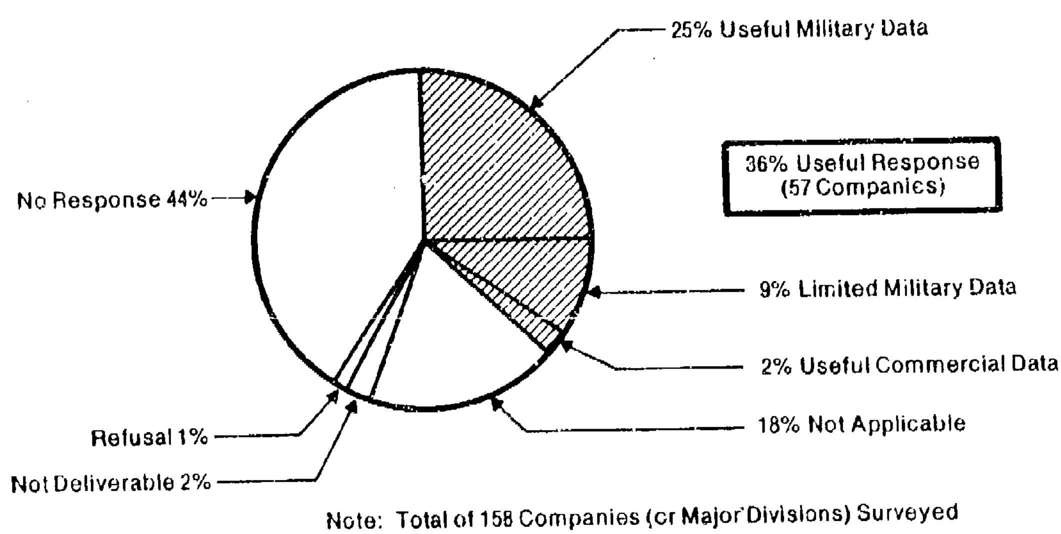



Figure 1. Survey Response

The largest response group was the 44% sector representing those companies who, for lack of applicability, interest, or whatever, did not provide any response whatsoever. The relatively large size of this category was probably due to the lenth of the survey questionnaire, and one other key factor - the mailing list was compiled from many sources, and the contacts were not necessarily qualified. It was decided to include all potentially interested firms, rather than to exclude some interested organizations by using a smaller mailing list. In addition to personal contact lists of appropriate Westinghouse personnel, names were obtained from trade society mailing lists, trade journal indexes and directories, and other sources. The 44% "No Response" and 18% "Not Applicable" categories attest to the over-mailing. About half of the 44% could realistically be considered "Not Applicable", in retrospect.

If only the potentially applicable responses were considered, the 57 useful responses represented an astounding 55% positive response. This excellent response represented over 800,000 hybrids produced annually, with a value of over $240,000,000. Only a few medium to large hybrid manufacturers are not represented. In other words, the survey data collected was representative of what the entire industry was doing. This data was very valuable for use in deciding the plan of action for the technical development portion of this contract. The data contained in these responses is discussed in the next several sections.

## D. PACKAGE USAGE AND TRENDS

Package usage was broken down in the questionnaire by style, size, plating, and seal method. Table I summarizes most of this information. The configurations are ranked in this table, with the most commonly used configuration at the top and the least common at the bottom. To help keep this table from becoming too cumbersome, the packages have been divided into three general categories by size. Packages which were roughly square have been divided into 1" x 1" and 2" x 2" categories. Packages which were clearly rectangular are listed as 1" x 2", unless they are so large or small as to better fit the other two categories. Packages over 2" on a side (of which there were only a few) have been grouped with the 2" x 2" category. Table I shows the monthly quantities used for each configuration and size.

Figure 2 illustrates the most common package styles in an open header condition. The planar lead "butterfly" package derives its nickname from the two sections of lead frame resembling the open wings of a butterfly. Strictly speaking, this style consists of a solid sidewall brazed to a flat base, with leads passing through the any and/or all of the walls. For this contract, no distinction was made bewteen the two piece version and a single piece version using a shallow, formed cup design. The bottom pin package with sidewalls is nicknamed a "bathtub" package; to understand this, picture the package with only the four corner pins in place. This style is usually of the one piece variety, but is available in the two piece, brazed construction. The third most common style has been called a

Table I. Military Hybrid Package Usage

| Package Type | Monthly Quantity | | | |
|---|---|---|---|---|
| | 1- × 1-in. | 1- × 2-in. | 2- × 2-in. | Total |
| Welded Butterfly | 20,160 | 6,270 | 900 | 27,330 |
| Welded Bathtub Plug-In | 9,590 | 6,370 | 70 | 16,030 |
| Welded Platform Plug-In | 7,850 | 100 | 10 | 7,960 |
| Soldered Ceramic Butterfly | 200 | 4,600 | 0 | 4,800 |
| Soldered Platform Plug-In | 2,140 | 100 | 0 | 2,240 |
| Welded Power Hybrid | 1,100 | 500 | 500 | 2,100 |
| Soldered Integral Substrate | 1,650 | 410 | 0 | 2,060 |
| Soldered Butterfly | 1,340 | 450 | 10 | 1,800 |
| Soldered Bathtub Plug-In | 120 | 1,210 | 100 | 1,430 |
| Others | 300 | 1,000 | 0 | 1,300 |
| | | | | 67,050 |

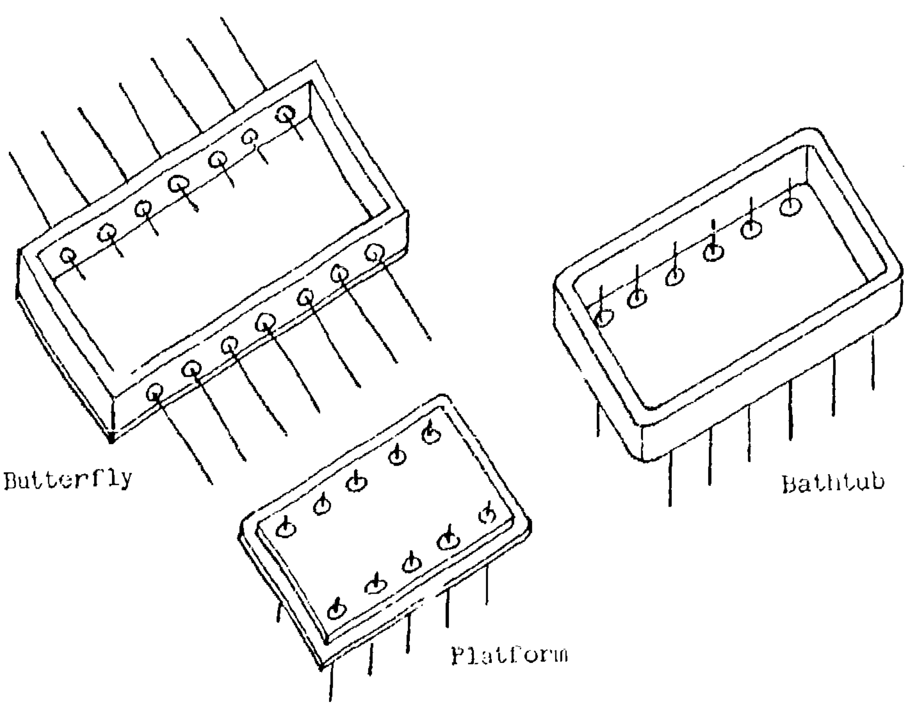



Figure 2. Common Package Styles

"platform" package. It consists of a flat plate with leads straight through it. Though they are sometimes solder sealed, these packages are typically "projection" or "one-shot" welded. To facilitate projection welding, the top edge of the header is built with a raised, sharp projection around the entire perimeter. (This welding technique is used on almost all T-O cans.)

For convenience, Table II shows a breakdown of the more common configurations as a percent of the total usage. Please keep in mind that these tables, and the other data being presented, represents only data from the survey responses. The data does not represent the entire industry, although it does provide a good cross-section of industry usage.

It is immediately clear from Tables I & II that welded metal 1" x 1" butterfly packages were the dominant configuration with 30.1% of the total package usage. This was consistent with the 1"x 1" category easily being the most common size (66.3% of total), and welded metal butterfly being the most common configuration (40.8% of total). The three most common configurations were all weld sealed. In fact, 80.5% of all the packages were weld sealded, leaving less than 20% solder sealed. Metal packages dominated ceramic, with almost 90% of the market. Approximately 90% of the metal packages had gold plating as a final finish, with the majority of the remainder having a nickel finish. A variety of special packages were used in limited quantities for special applications, such as high power or optics.

Table II. Commonly Used Packages As Percent of Total Use

| Package Style | Percent of Military Market | | | Total |
|---|---|---|---|---|
| | 1 × 1 in. | 1 × 2 in. | 2 × 2 in. | |
| Welded Metal Butterfly | 30.1% | 9.4% | 1.3% | 40.8% |
| Welded Metal Bathtub | 14.3% | 9.5% | 0.1% | 23.9% |
| Welded Metal Platform | 11.7% | 0.2% | 0.02% | 11.9% |
| Soldered Ceramic Butterfly | 0.3% | 6.9% | 0% | 7.2% |
| Soldered Metal Platform | 3.2% | 0.1% | 0% | 3.3% |
| Welded Power Hybrid | 1.6% | 0.8% | 0.7% | 3.1% |
| Others | 5.1% | 4.5% | 0.2% | 9.8% |
| Total (800,000 Hybrids/Yr) | 66.3% | 31.4% | 2.3% | 100.0% |

Several trends were discernable from the survey data. Packages sizes are increasing. Many hybrids using packages too small to be tallied in this report will be redesigned into 1" x 1" category packages. Use of 1" x 2" and even 2" x 2" packages is increasing. (Since circuit complexity is often related to package size, these large packages may require more reworking, including delid/reseal.) Metal-bodied packages have taken over from ceramic-bodied packages, but ceramic may retain a small foothold through increasing use of integral substrate packages and large ceramic chip carriers. Metal packages usually can be welded or soldered, but welding is continuing to replace soldering. One reason for this is the advantage welded packages have for resealability. Also, by mounting substrates with epoxy and weld sealing the package, the need for expensive gold plating on the package body is eliminated. Use of nickel for the final plating finish is slowly gaining acceptance, and will be well underway in five years. Finally, there is an increasingly varied selection of specialty packages for high power, high speed, optics, microwave, and other applications.

## E. REWORK QUANTITIES

Rework options for sealed hybrid packages were defined and discussed in the introduction to this report. Rework quantities reported in the survey responses seemed to be on the conservative side, and in some cases, data (especially scrap levels) the data was not provided. Perhaps this was to avoid presenting possibly embarrassing data. The first rework option, scrapping the hybrid, was resorted to on 0.2% of the packages, according to survey data. Delidding the package and subsequently remounting the substrate in a new package was performed on 2% of the packages. Table III provides a breakdown of the quantities delidded and resealed for each of the most common package configurations. Although only 5% of the total quantity of hybrids built are delidded and resealed, those companies which have a delid/reseal technique that they consider acceptable perform delidding and resealing on 10-15% of the packages which their technique accommodates. (For example, if their technique is useful only for welded butterfly packages, 10% of their welded butterfly packages will be delidded and resealed; soldered packages and other styles of welded packages may not be delidded and resealed at all.) This figure still does not completely represent the quantity of reseals, since many packages are resealed several times.

Another important fact to keep in mind is that delid/reseal is extremely important during the prototype and pilot run phases. During the early stages, hybrid circuits often undergo considerable rework/repair due to design changes, inadequate or incorrect parts, electrical malfunctions, and other reasons. The survey data confirmed this; for example, some small companies which specialize in building unique or prototype hybrids delid virtually every package at least once, and often several times. The capability to easily delid, rework, and reseal a package is a tremendous advantage, since the hybrid is quickly and inexpensively reworked (minimizing new hybrid development time and cost is very important). Details of welded and soldered package delidding are presented in the next two sections.

Table III. Monthly Quantities Delidded and Resealed

| CONFIGURATION | SIZE 1 X 1 | 1 X 2 | 2 X 2 | % of Total |
|---|---|---|---|---|
| Welded Metal Butterfly | 1,444 | 602 | 40 | 7.6 |
| Welded Metal Bathtub | 194 | 182 | 8 | 2.4 |
| Welded Metal Platform | 0 | 0 | 0 | 0 |
| Soldered Ceramic Butterfly | 1 | 540 | 0 | 11.3 |
| Soldered Metal Platform | 206 | 10 | 0 | 9.7 |

F. WELDED PACKAGE DELIDDING

Hybrid manufacturers have devised numerous methods for removing the cover from a weld sealed hybrid package. Some methods are destructive to the package body, and are not suitable when resealing is desired. For failure analysis, or perhaps for repackaging, these techniques may be acceptable. An example is using pliers to peel the lid off, somewhat like opening a can of sardines. Delidding techniques used for welded packages are covered in Table IV, ranked with the most commonly used technique at the top.

End milling is used by 14 companies, making it the most prevalent technique. Various designs incorporating a rotating saw blade account for the second most common technique. Although end milling is used by more companies, sawing is used on more packages by a five to one margin. (This data is from the time of the survey; due to the success of this contract, sawing now is more common and has a larger frequency of use margin.) Hand sanding is typically used for very low volume operations, but it does rank as the third most common method for removing a welded lid. In almost every case, these delidding techniques required subsequent dressing of the seal flange prior to resealing in order to remove burrs or other irregularities.

Table IV. Welded Package Delid Techniques

| Technique | No. Companies | Reseal Cycles | Dressing Used |
|---|---|---|---|
| End Mill | 14 | 1 to 3 | Knife or Sand |
| Saw | 11 | 1 to 5 | Sand |
| Hand Sand | 6 | 1 to 2 | Sand |
| No Delid | 5 | 0 | N/A |
| Surface Grind | 4 | 1 to 3 | Knife |
| Knife Blade | 1 | 6 | Unknown |
| Laser Machine | 1 | 2 | Unknown |

Most of the companies reported that delidding and resealing could be performed successfully twice on a given package; a few limited reseals to once, while others claimed three or more. Each instance where 5 or more reseals are performed are for closely controlled laboratory conditions, not full scale production. For example, one company using a sanding approach followed by brush plating to achieve 5-10 reseals on a handful of packages. It is worth noting that 5 of the respondents do not delid and reseal any production hybrids; delidding, if any, is confined to experimental circuits. This is not to say that these companies do not feel delidding is undesirable, on the contrary, they would like to have that option but have not been able to obtain the necesary waiver to Mil-M-38510.

Several of these companies were the most enthusiastic about the survey and this contract, in anticipation of reaping the rewards of a successful completion. One company is using a proprietary stoppered knife approach; it is believed that multiple reseals are routinely achieved, but details of the o[illegible]tion were closely guarded. Laser machining is used to remove lids from packages at the only company which identified laser sealing as a production technique.

In order to determine which technique is best for a given package configuration, it is necessary to understand how each technique is typically performed. It is then be possible to compare and contrast the approaches, and ultimately choose the approach which is best suited for that package configuration. Additional details of welded package delidding are presented in section IV.B, which discusses selection of the delid approach used for this contract effort.

## G. SOLDERED PACKAGE DELIDDING

Table V lists delidding techniques for soldered packages, in the same manner as just presented for welded packages. Several variations using a knife blade help make this approach the most common. The two most common designs are use of a guillotine style shearing blade and use of an X-acto knife or equivalent. Sometimes a hot plate is used in conjunction with the knife blade. Use of a hot plate alone or a manual soldering iron are the other common solder delid techniques. One company uses a solder pot to heat the domed (tophat) lids of their soldered packages until the lid falls off the inverted package. Another unique approach is used in a laboratory operation where an in-house designed machine applies heat to the seal flange area of platform packages; by controlling the pressure and vacuum applied, the lid can be soldered on or removed many times. A technique not recommended for production use, but sometimes used for failure analysis, is to pry off the lid with pliers; this works best with brittle solders and strong packages.

As with welded packages, there are some manufacturers who do not reseal any production soldered packages, although they wish they could. Proportionally, there are fewer companies resealing soldered packages than resealing welded packages. Even those companies who do perform delid/reseal on soldered packages usually only do so once per package, though they occasionally reseal more often. In virtually every approach, a soldering iron is used to clean up and smooth off the seal flange in preparation for resealing. Additional solder is almost always added when resealing.

Table V. Soldered Package Delid Techniques

| Technique | No. Companies | Reseal Cycles | Dressing Used |
|---|---|---|---|
| Knife Blade | 6 | 1 to 2 | Solder Iron |
| Solder Iron | 3 | 1 | Solder Iron |
| Hot Plate | 2 | 2 to 3 | Solder Iron |
| APL Solder Sealer | 1 | 10 | None ? |
| Solder Pot | 1 | 2 | Solder Iron |

Typical problems encountered with soldered package delid/reseal include leaching or dewetting of the seal flange, solder balls and splatter, disturbing solder mounted components, and having to use higher temperatures for each reseal due to the solder alloying. In general, the softer, lower temperature solders (e.g. Sn 63/Pb 37) were easier to rework than the harder, higher temperature solders (e.g. Au 80/Sn 20). As for selecting one method over another, except for soldered platform packages, there are no outstanding choices. Each of the methods employs inexpensive equipment and tools, and to a varying degree (according to the individual company's specific design) can be performed fairly quickly in a manner which does not endanger the operator or the package. Ease of operation, particle control, and versatility also vary with the individual design. For soldered platform packages with tophat covers, the laboratory sealer mentioned is quite appealing. A commercial version should be forthcoming; its applicability for other package styles is not known.

## H. YIELD IMPACT OF DELIDDING AND RESEALING

Hybrid packages which have been delidded and resealed might be expected to exhibit lower yields when subjected to screening tests. The survey data shows this to be true to some degree. Fine and gross leak test yield was reported to be unchanged by 45% of the respondents, even after two delid/reweld cycles on the same package. A 5% yield drop per reseal cycle was indicated on 25% of the responses; 10% of the responses reported a 10% drop each reseal cycle. The remaining 20% did not report any leak test data. Yield impact of delid/reseal on soldered packages was not adequately reported. The few companies reporting specific data show approximately 5% drop per reseal cycle. Recalling that soldered packages were typically resealed only once, it is apparent that soldered package delid/reseal must exhibit decreased yields.

Particle impact noise detection (PIND) test data was very difficult to obtain, for several reasons. First, fully two-thirds of the companies responding PIND test less than 10% of their product, representing their High Reliability hybrids which require this test. Second, PIND testing is controversial; few companies, if any, are really satisfied with this method for detecting particles in sealed hybrids, and no companies are willing to disclose actual PIND test yield. (The pros and cons of PIND test could be discussed at length, but that is beyond the scope of this contract.) Three respondents did provide a clue to the impact of delidding and resealing on PIND test yield, however. One company reported no change in yield, while two others cited unspecified decreases in PIND test yield.

No data was collected specifically for electrical test yield impact, or for the various environmental and mechanical tests. All but one response verified that resealed packages are subjected to the same screening tests as packages going through for the first time, and that the test criteria remain the same. One response indicated that resealed packages were not subjected to all of the tests, though burn-in was still performed.

## I. COST IMPACT OF DELIDDING AND RESEALING

Delidding and resealing is already having a favorable cost impact, since many companies are performing delid/reseal on at least some of their product. The companies providing figures for cost savings due to present techniques reported a combined savings of $2.5 million annually. If a method were made available for delidding and resealing their most common package configuration, and Military specifications allowed two delid/reseal cycles, survey responses estimate that $5 million would be saved each year. Extrapolating this to cover their other package configurations, and to include those companies which did not provide data (including those companies which did not respond to the survey at all), it is projected that the total potential cost savings is in exceess of $10 million annually.

Applicability of delid/reseal for field returns was also probed, with 65% of the survey respondents favoring this. Several firms did place some restrictions or extra requirements on such reworked packages, however, such as a more stringent glass bead inspection. Potential savings from delidding and resealing field returns was estimated to exceed $300,000 each year, by those firms favoring resealing of field returns.

## J. INDUSTRY RECOMMENDATIONS FOR DELIDDING AND RESEALING

It is quite obvious from the preceding data that the Industry feels the need to delid and reseal hybrid packages on occasion. Multiple delid/reseal of a given package is necessary sometimes, and is feasible (packages can be designed to minimize package damage during delid/reseal, such as by having the glass to metal seals located well away from the weld region). The Industry is overwhelmingly in favor of amending Mil-M-38510 to allow delidding and resealing of hermetic hybrid microelectronic packages. A limit of two delid/reseal cycles per package is often mentioned, while some firms recommend higher limits, especially since some designs offer inherently better reworkability.

End milling is well established as a delidding technique, and some companies may be slow to change to anything new, but precision sawing was the most often recommended technique. Indeed, some companies currently utilizing end milling recommended sawing. The principal reason for this was that a saw machine designed especially for delidding hybrids came on the market. While the new machine was not fully proven in the field, it offered enough advantages that many companies were investigating buying one at the time the survey was made. At the time this report was being prepared, 30 of the new saws were in use or on order. Eight companies were switching from end milling, four from grinding or sanding, and four more from in-house designed saws. (Most of these 30 machines incorporate some or all of the modifications which resulted from this contract effort.) Complete details of the new saw are presented in the next sections. Resistance welding, utilizing a parallel seam weld sealer, was the favored sealing and resealing technique.

## IV. SELECTION OF PACKAGE CONFIGURATION AND DELIDDING APPROACH

### A. PACKAGE CONFIGURATION SELECTION

Selection of the package configuration was based on several aspects of the Survey data. Basically, the configuration selected was to be that which offered the greatest potential benefit to the Military due to developing a delid/reseal capability. Factors considered were the actual quantity of packages used, the value of the hybrids using them, the likelihood that delid/reseal would be needed, and the predicted trend for use of that package.

Survey data showed that the 1" x 1" welded metal butterfly package to be the prime candidate, at first glance. More thorough evaluation, however, shows a more appropriate choice for the purposes of the contract. Larger packages, such as 1" x 2", are becoming more common, and are harder to effectively delid/reseal due to their larger geometries and greater number of glass to metal seals. A typical 1" x 2" package, for example, not only has longer sides over which a flatness tolerance buildup can be very significant, but the number of glass seals is much greater. The glass to metal seals are typically the weakest part of the package, and are an important consideration during delid/reseal. Another reason for choosing the larger package is that a reasonably complex circuit could be chosen, one that would be meaningful during the Qualification Testing which was to be performed. Finally, any delidding technique developed for 1" x 2" packages would almost certainly be directly applicable to smaller packages.

For these reasons, the package configuration selected for use as the test vehicle was a 1" x 2" welded metal butterfly package (figure 3). Packages were obtained from two different vendors, who provided similar 68 and 74 pin packages. All of the packages were plated with 100-200 microinches of gold over the same thickness of electrolytic nickel. Chemically etched step lids were used for sealing the packages. The lids were 15 mils thick in the center and 5 mils thick at the edge. Lid plating was identical to the package plating. All sealing and resealing was performed on a resistance seam welder equipped with dual rolling electrodes and independent capacitive discharge power supplies.

### B. DELID APPROACH SELECTION

With the welded butterfly package configuration in mind, it was necessary to select the delidding approach which was best suited to this particular package. Each of the available delidding techniques had to be compared for applicability, and probability of success. The advantages and disadvantages of each technique had to be weighed, considering such factors as operator safety, speed of set up and operation, surface finish, operator skill required, particle control, and applicability to other package configurations. Table VI compares the most common welded package delidding techniques, as explained in the following paragraphs.

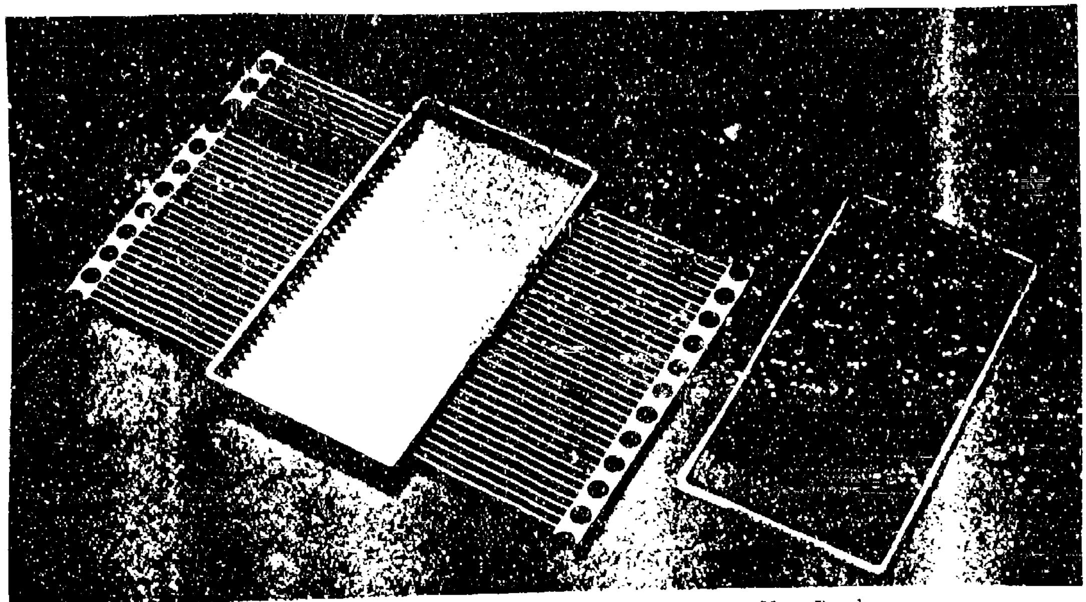


Figure 3. 1" x 2" Welded Metal Butterfly Package

Table VI. Weld Delid Techniques Comparison

| Criteria | Delid Method Saw | Mill | Sand | Grind |
|---|---|---|---|---|
| Safety | G | P | G | F |
| Ease | G | F | G | F |
| Speed | G | F | P | F |
| Burr Occurrence | G | F | F | F |
| Surface Finish | F | F | G | G |
| Particle Control | G | P | P | P |
| Equipment Cost | F | F | G | F |

G - Good F - Fair P - Poor

Operator safety is not a grave concern when hand sanding a lid off. Belt sanding involves some danger. Worse yet is end milling, where the operator is often hunched over, watching an exposed cutting tool as it machines away the weld and throws metal particles in all directions. The best saw machine, on the other hand, has a well protected blade, and no particles escape the machine housing. The housing also serves to keep the operator out of the drive pulleys. The fact that the operator has their hands well away from the machine during most of the delidding process also helps to prevent any possible injury.

Hand sanding is fairly easy, although it does take some care to sand just the right amount off around the entire package. Grinding and milling are comparable for ease of controlling the cut and adjusting for other sizes and styles of packages. Some companies have developed fixtures that make positioning the package easier and more precise than trying to use a plain vise. Some companies delid by making one continuous cut around the entire package perimeter; others cut one side at a time, repositioning the package between sides. All of the milling approaches use the bottom of the package as the reference plane, although the top and bottom of the package each have a planarity tolerance, and are not usually required to meet a specific parallelism dimension. This introduces an uncertainty in the cut depth required to remove the lid. The saw is operated by a few buttons, with simple knobs providing all of the cut control needed. Adjustments can be made in seconds for other package sizes, with the lid of the package providing an accurate reference plane, independent of package size. Whereas milling and grinding require a skilled machinist, sawing can be safely and adequately performed by a low skill operator.

Sawing has the speed advantage overall, requiring one fast cut down each side of the package; the only adjustment necessary is for the length of the side (cut two long sides, adjust, cut two short sides). Set up and changeover to other configurations is usually faster on the saw than on the mill or grinder, also. Hand sanding has a decided disadvantage with regards to speed.

Most delid methods require some dressing of the seal flange after delidding in order to remove burrs or irregularities. Hand sanding and a sharp knife of some type are the common methods for dressing the flange. Besides exposing the circuit to additional particle generation, these dressing operations subject the package and circuit to a very definite potential for damage. Sawing, through better positional control and an optimized cutting speed which is not operator dependent, eliminates most need for deburring.

The surface finish achieved by sawing is comparable to end milling, with one key difference. Sawing causes machining marks which run along the length of the seal flange. End milling, since it uses a rotating cutting instead of a linear cutting, causes machining marks which traverse the width of the seal flange . This provides the opportunity for a very short and direct leak path. Sanding and surface grinding can achieve a better surface finish by utilizing fine grit wheels and abrasive paper. The seal flange can be made to be very flat and smooth, which facilitates resealing and any subsequent delid/reseal.

Unfortunately, the very smooth surface is obtained by making a large amount of very small particles which are extremely difficult to completely remove from the package. Particle control is one of the most important requirements for successful delidding and resealing, especially for hybrids which must pass PIND test. A vacuum particle pickup is useful, but not completely adequate for controlling particles. The saw technique has several built in features which provide it with unsurpassed particle control; specifics are provided in the section describing the machine in detail.

Another relevant factor is the cost of acquiring, installing and operating the equipment. Equipment for each of these techniques can be purchased for $8-12K, although it is possible to spend considerably more to get a programmable table, larger capacity, or top quality. Considering the value of the product being delidded, the cost of any of the basic machines would be quickly amortized in a production environment. Although sanding equipment is the least expensive, this approach is not really suited to production volumes.

In summarizing the delid options for welded packages, especially butterfly packages, sawing has the advantage over the other production techniques for every category except surface finish. Sawing is safest, has the fastest set up and delidding, uses a lower skill operator, eliminates most deburring, and has the best particle control. While not every saw design has all these advantages, the one singled out by the Survey respondents does. Another advantage of the saw machine selected is that it will delid several styles of packages easily, not just butterfly packages.

Sawing clearly was the most promising delid technique, and the Sharp Precision Model SP110 Microcircuit Cover Remover was the most interesting and promising design. Although it was brand new at the time, and needed to be refined, debugged, and field-proven, the SP110 was judged to be the best starting point for delidding equipment. A complete description of the machine and its theory of operation are presented in the next section.

## C. DESCRIPTION OF DELIDDING EQUIPMENT AND PROCESS

This section describes the design of the machine selected, and the theory of its operation. Details of how it worked in actual use, and the changes that were made to it, are presented in the next section.

The Sharp Precision Model SP110 Microcircuit Cover Remover (figure 4) is designed especially for delidding hybrid packages. This machine employs a rotating saw blade in a configuration resembling a table saw for cutting wood. Special design features and precise controls enable the SP110 to quickly and safely remove welded covers from butterfly and bathtub packages. Packages up to 3" x 3" x1/2" can be accommodated. Resealing is easily accomplished with a new lid, since the seal flange is smooth and clean enough to weld directly onto the machined area. The SP110 is a self-contained

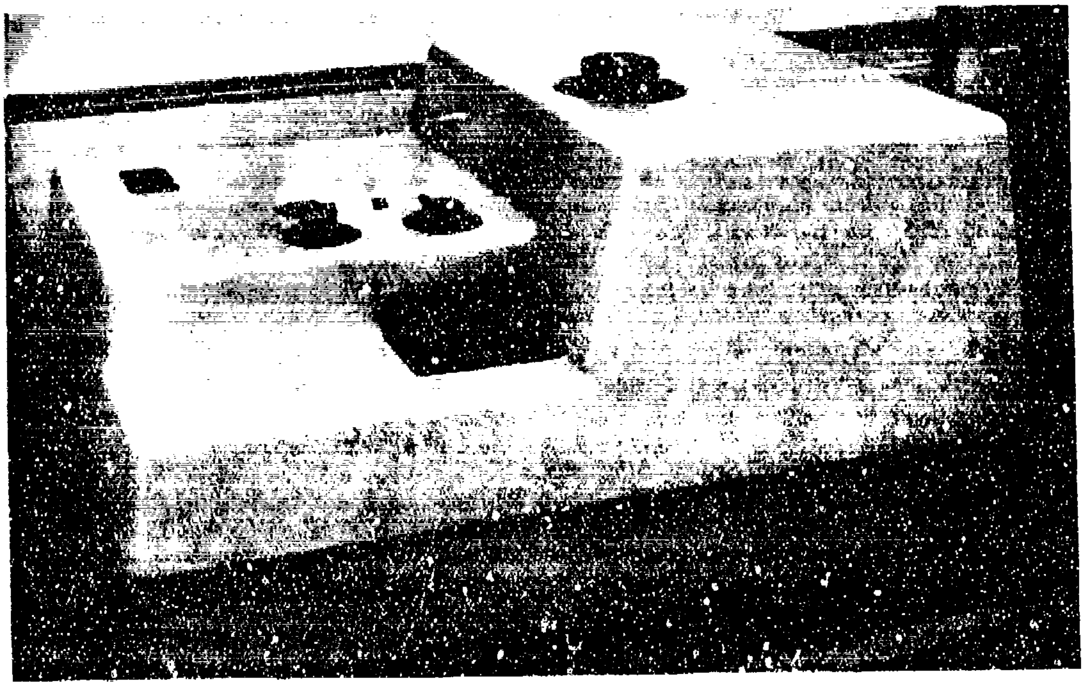


Figure 4. Sharp Precision SP110 Microcircuit Cover Remover

benchtop unit which can be operated within a hybrid assembly area; the only hookups are 110 V and 80-120 psi compressed air or nitrogen. A banana plug receptacle is provided for the operator's ground strap.

Figure 5 is a front view of the machine with the top half of the protective fiberglass housing raised up. In the foreground is the pneumatic slide table, with the pneumatic clamp assembly above it. The saw blade cannot be seen from this angle; it is located behind the table, approximately one-third of the distance from the right hand end of the table. Figure 6 shows the rear view, dominated by the vacuum motor housing on the left and the drive pulleys on the right. The saw blade is mounted on the other end of the shaft with the large pulley. A small motor on the right drives the saw blade.

To delid a package, the operator first sets the knobs for cut width, cut length, and cut depth (Figure 7); the cut width is 10 mils less than the wall thickness, the cut length is simply the length of the package side being cut, and the cut depth is equal to the thickness of the lid (in the weld region). Once these are properly set, the cut width and depth knobs need no further attention. The cut length knob will be adjusted as necessary to match the side being machined at that time.

Next, the operator places the package face down on the machine's slide table, and pushes the package into the reference corner. One edge of the package, e.g. a long side, will be overhanging the edge of table and will be machined momentarily. With the package face down in this corner, the machine is able to make an accurate cut by referencing the top of the package and two adjacent walls.

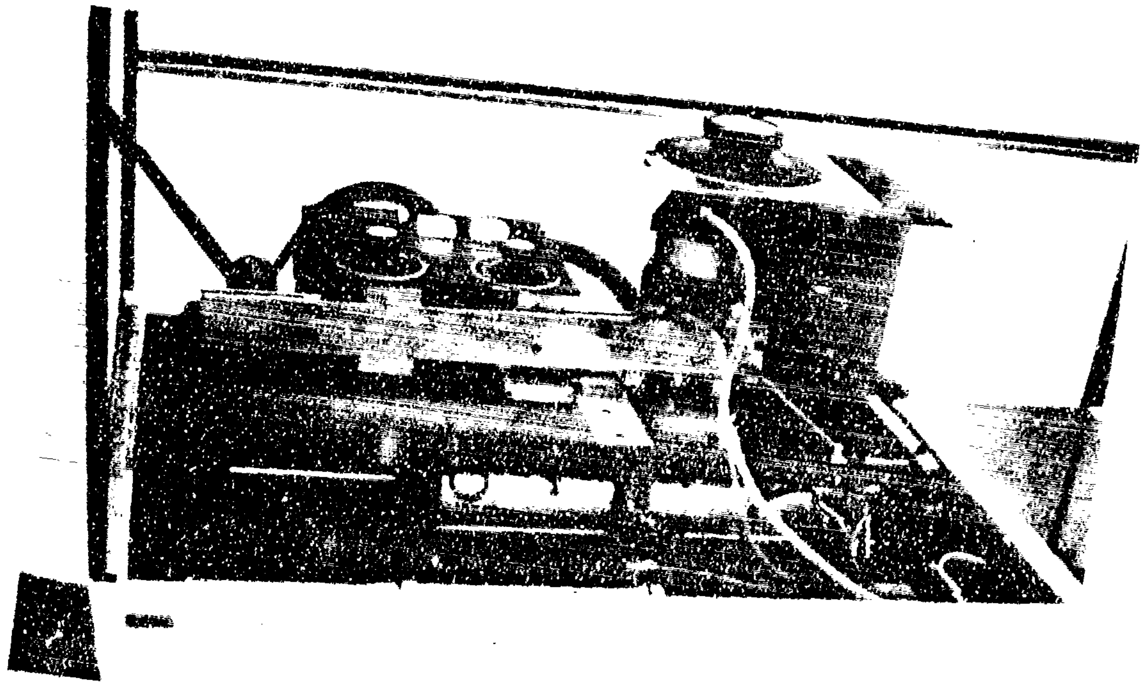


Figure 5. Front View of SP110 With Cover Raised

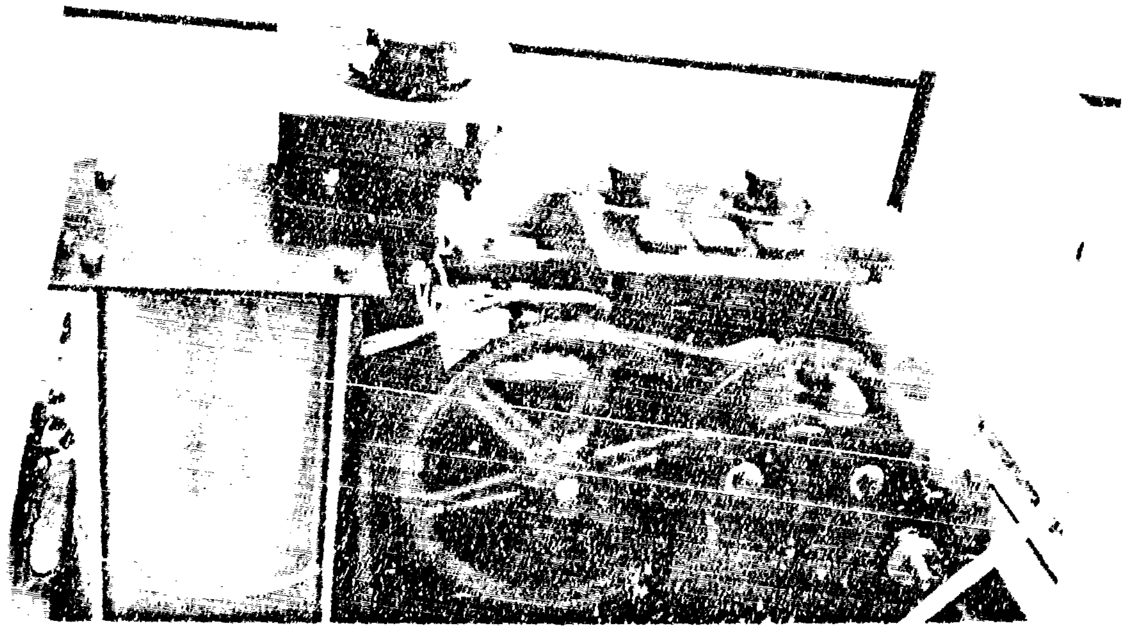


Figure 6. Rear View of SP110 With Cover Raised

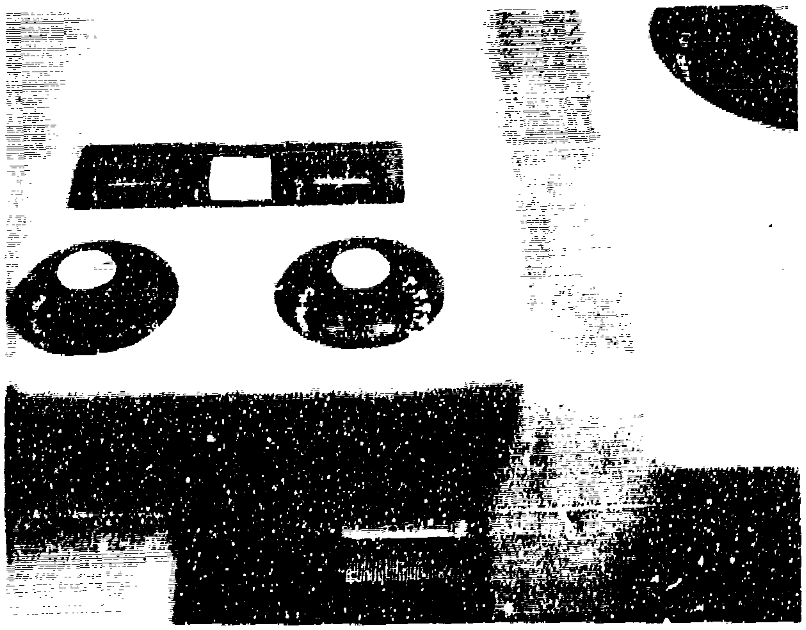


Figure 7. Operating Controls of SP110

Depressing the POWER button causes the saw drive motor to start up. Pressing the CLAMP button activates the pneumatic driven clamp to descend, clamping the package to the table. The clamp itself is a pivoting bar designed to distribute the clamping force evenly over the package. Holding down the START button momentarily causes the slide table to start advancing the package towards the saw blade. The portion of the package which overhangs the table gets machined as the table continues to advance, passing the package over the saw blade (figure 8). After the entire side has been machined, the table automatically returns.

One long side of the package has been machined now. The operator again presses the CLAMP button, causing the clamp to raise up. The operator rotates the package 180°, clamps the package again, and starts the table. When the second long side has been machined, the operator must make one adjustment before continuing with the two remaining short sides; the cut length knob must be adjusted for their length. If the package is square, this step is not necessary.

Once all four sides have been machined, the package is removed from under the clamp. When the package is lifted up, the lid will remain behind on the table. If the lid is still attached to the package, a tapping thepackage gently on the table will cause the lid to fall free. At this point, the package physically can be resealed without dressing or cleaning the flange. Of course, circuit repair is normally performed first, along with inspection, test, and cleaning. Dressing the flange is not necessary as a rule; if needed on an occasional package, a knife blade is recommended.

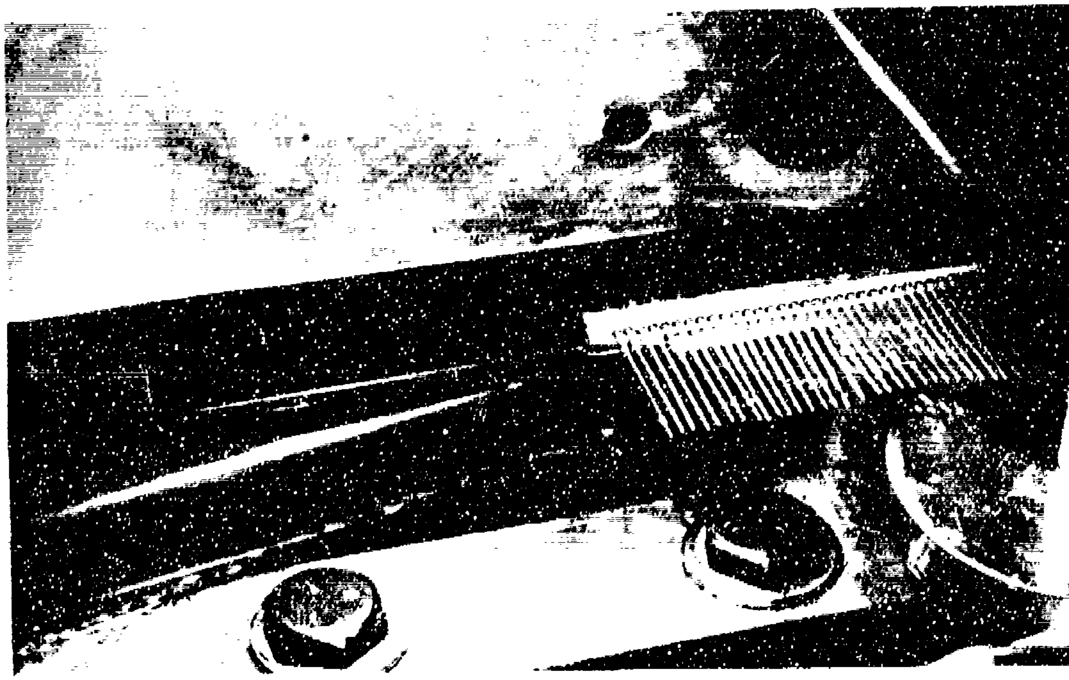


Figure 8. Package About to be Machined

Dressing the flange after delidding usually introduces some particles into the package. The delidding operation itself does not; several design features work together to prevent particles from getting into the circuit. First, the package is delidded upside down, so any particle entering the package would land on the lid, not the substrate. Second, a strong vacuum pickup is located almost flush with the saw blade, collecting almost all of the particles as they are created. Third, the cut width is restricted to less than the width of the seal flange or package wall. This is important for particle control, since the clamp keeps the lid clamped to the remaining portion of the seal flange, providing a physical barrier to particles.

Furthermore, by not cutting the whole width of the wall, the lid cannot fall into the package. If the cuts were made too wide and the lid did fall in, not only would the wirebonds be smashed, but the top of the lid would have moved with respect to the seal flange, invalidating the reference plane for depth of cut. This results in subsequent cuts being too deep, cutting down into the seal flange.

Normally, it is possible to avoid cutting too far if the package seal flange is flat. If the seal flange is warped, then some overcutting will result at the high points when the depth of cut is increased enough to ensure the lid is completely machined through at the low points. A step will result, as shown in figure 9. Another way a step can result is if two adjacent cuts are not the same depth (figure 10); this can result from the knob being changed between cuts, from a badly warped package, or from the slide table needing a planarity adjustment. Steps of up to two mils are acceptable, as discussed in the Process Development section .

To save a little bit of time, the operator need not reset the cut length for the adjacent side, but can start cutting the same side on the next package. For example, after finishing one package by cutting the short sides, the next package is machined short sides first. This pattern of alternation will eliminate one adjustment, without affecting the cut quality.

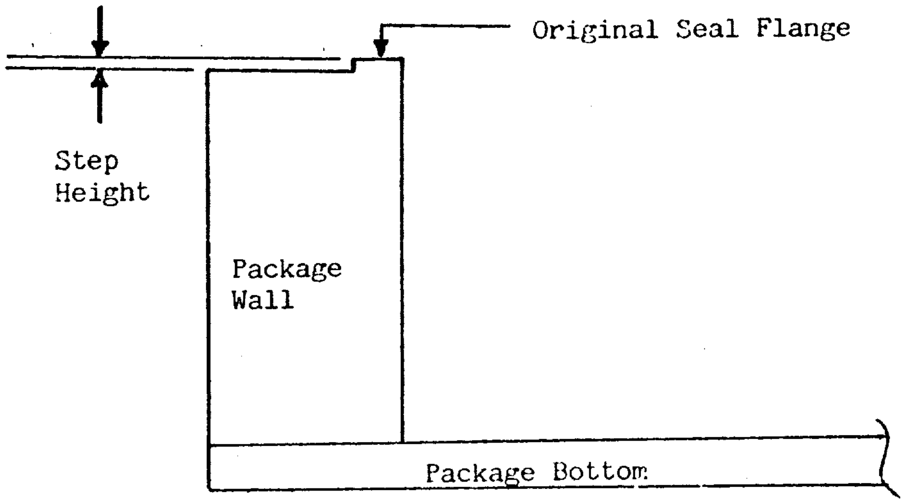



Figure 9. Step Caused By Machining Too Deep

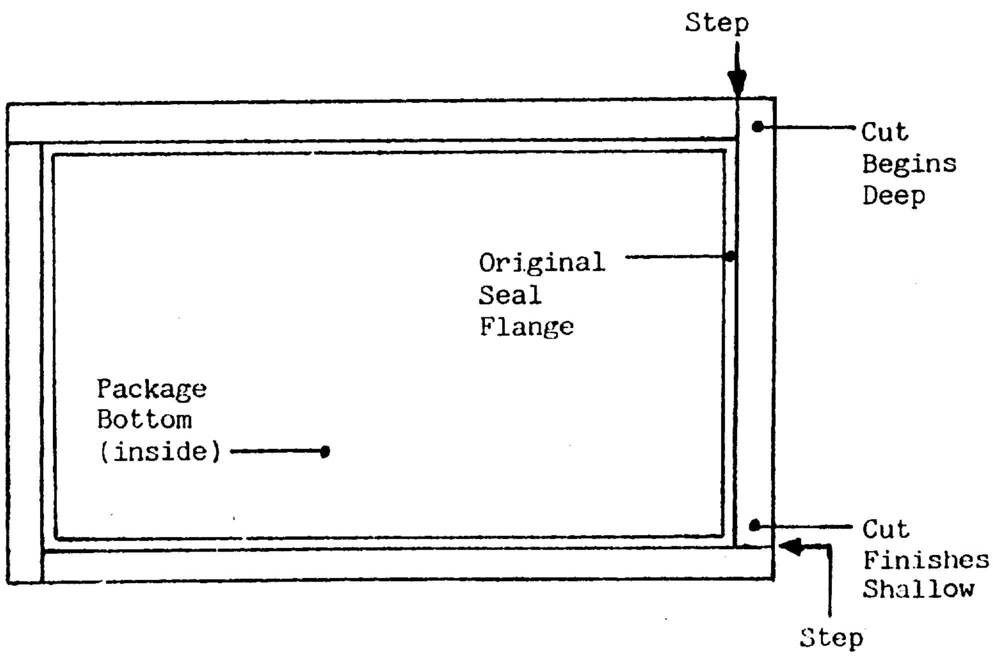



Figure 10. Step Due to Cut Depth Mismatch

## V. EQUIPMENT AND PROCESS DEVELOPMENT

### A. EQUIPMENT DEVELOPMENT

The preceding section discussed how the delidding equipment works in theory. In actual use, there was great need for improvement. Numerous modifications and redesigns were made to almost all major elements of the delidding machine. Some changes were implemented to improve or extend the machine's performance capability. Others were concerned with ease of operation and adjustment. Still others contributed to improved operator safety. Table VII lists a representative sampling of the measures taken to improve the equipment design. Sharp Precision has incorporated these improvements and others in their new Model SP112 delidder.

Originally, the motor which drives the saw blade was vented inside the fiberglass machine housing. The motor housing exceeded 75°C during operation, while the motor's exhaust warmed everything inside the housing to over 45°C, and higher in the direct path of the exhaust air. Heating the precision slide table and other machine elements introduced an unacceptable amount of warping and expansion. Due to the criticality of controlling cut dimensions, any misalignment or instability was disastrous. This thermal instability was mostly avoidable by operating the equipment with the cover raised, but this exposed the operator to the moving parts and caused the perceived machine noise level to increase markedly.

Table VII. Delidding Equipment Improvements

| Machine Limitation | Solution |
|---|---|
| 1. Blade Chattered | 1. Improved Mounting Design and Modified Blade Design |
| 2. Difficult Clamp Height Adjustment | 2. Redesigned Clamp Height Adjustment |
| 3. Thermally Unstable | 3. Exhausted Motor Externally |
| 4. Clamp Actuator Intermittent | 4. Modified Solenoid |
| 5. Exposed Electrical Terminal Strip | 5. Added Cover Plate |
| 6. Excessive Vacuum Noise | 6. Added Muffler |

Capping the exhaust on the end of the motor, and exhausting air outside the machine housing allows the heated air to be expelled harmlessly into the room. This was accomplished by providing a large hole directly through the motor housing and a matching hole through the equipment baseplate. A gasket provides an air seal between the motor and the baseplate. Solid objects, such as fingers of inquisitive operators, are kept out of the motor itself by a stiff, coarse screen over the hole opening. Only the motor now gets warm; the table and other components remain dimensionally stable at room temperature.

Saw blade chatter results from feeding the package into the path of the saw faster than the blade can easily machine the package away. Of course, if the blade is dull or damaged, chatter occurs easily. Even when the blade is sharp, perfectly round, and mounted tightly to the drive shaft, chatter can occur. If the belt on the drive pulley is not under proper tension, the belt can slip when the blade is trying to cut. Also, if the drive shaft is not properly mounted, vibration can be introduced more easily; this can occur if the bearings are not quite right or if a twisting force is being exerted on the spindle due to misalignment. Minimizing the shaft length is another technique for designing out chatter.

One other avenue that was pursued was to improve the design of the saw blade itself. Originally, the saw blade was found to clog up some as it machined away the metal. Kovar is not as free-machining as aluminum, or most other steels. Changing the rake angle of the saw blade's teeth from $5^{\circ}$ to $10^{\circ}$ enabled the blade to make a cleaner cut, since the teeth did not hold onto the machining particles.

Several bugs in the pneumatic system had to be worked out. For example, the solenoid controlling the package clamp would intermittently stick, refusing to lower the clamp. Investigation showed that the plunger in the solenoid was able to move far enough that the solenoid did not have the strength to pull it back from that far away. A simple fix was to use washers to limit the plunger travel, eliminating the overtravel. Consistent clamp operation resulted.

Routing and attachment of the tubing within the machine housing needed some minor improvements. A particle filter was added to the input line to protect the equip]ment's inner workings. A input line pressure gauge was added next to tge relocated regulator and clamp pressure gauge.

Adjustment of the clamp height is necessary to prevent the clamp from taking a running start at the package, and to prevent the package from riding up over the backstop. (The backstop is part of the reference corner scheme -- moving the backstop closer to or farther away from the edge of the table controls how much the package overhangs the table, and thus, how wide the cut will be.) As originally developed, the clamp was easily adjusted over a small range for normal or very high packages, but changing between these two was inconvenient. Changeover required a partial dismantling of the clamp assembly and repositioning the clamp bar itself. Accommodating in-between package heights was difficult. Redesign of the height adjustment to a simple, single screw technique allowed easy and continuous adjustment over the entire range.

Another modification implemented for the convenience of the operator was adding a muffler to the vacuum motor. Operators using the machine, and operators in the vicinity, objected to the loud cutting noises and the high pitched whine of the particle collection vacuum motor. Cutting noises were reduced by reducing blade chatter. A baffle network was added to muffle the sound carried in the vacuum motor exhaust.

Operator safety was already well thought out in the equipment in order to comply with OSHA requirements in California, the equipment's state of manufacture. Two small plastic covers were added to electrical terminal locations to help prevent short circuiting or electrical shock. Both of these would be difficult with the fiberglass housing closed, but occasionally it was desirable to operate the machine open, such as when adjusting the slide table planarity.

Two changes were made to the table itself. First, the screws holding the main table section down to the slide assembly were changed from flat head screws to cap head screws in order to provide better clamping forces with less critical hole drilling. Second, the front stop of the reference corner was changed from a long straight edge to a short straight edge plus a $45^{\circ}$ slant edge. The slanted edge is used when delidding packages with large corner radii. Since the delidder cuts a straight path of limited width (10 mils less than the wall thickness), it was possible for two adjacent cuts to miss part of the weld in a rounded corner (figure 11). In order to remove the weld in this region, the package was placed in the reference corner at a $45^{\circ}$ slant; the blade now had full access to the package corner. It was possible to make the slant cut with the prior design, but the package corner was very far from the front stop plate. Centering the clamp over the corner made the machine think it had to cut a very long side, wasting a lot of time. Adding the slant to the plate allow the package corner to be positioned very close to the plate (figure 12), minimizing table travel time.

Operators who had the opportunity to use the original design machine have responded extremely favorably to the current design. Those unfamiliar with anything but the end product found the equipment easy to use and were very pleased with getting away from sanding and other methods previously utilized in-house.

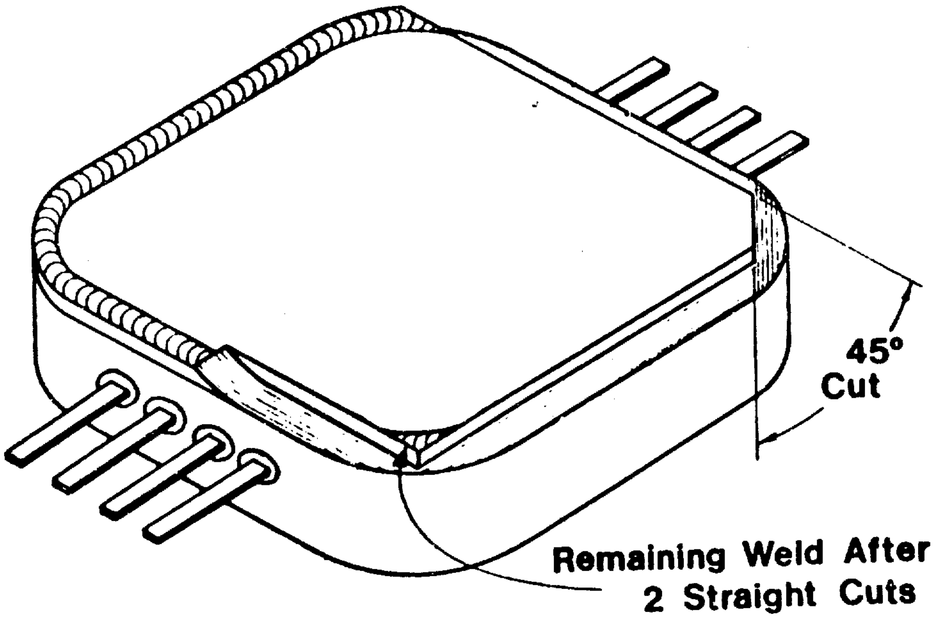



Figure 11. Missed Weld Region In Rounded Corner

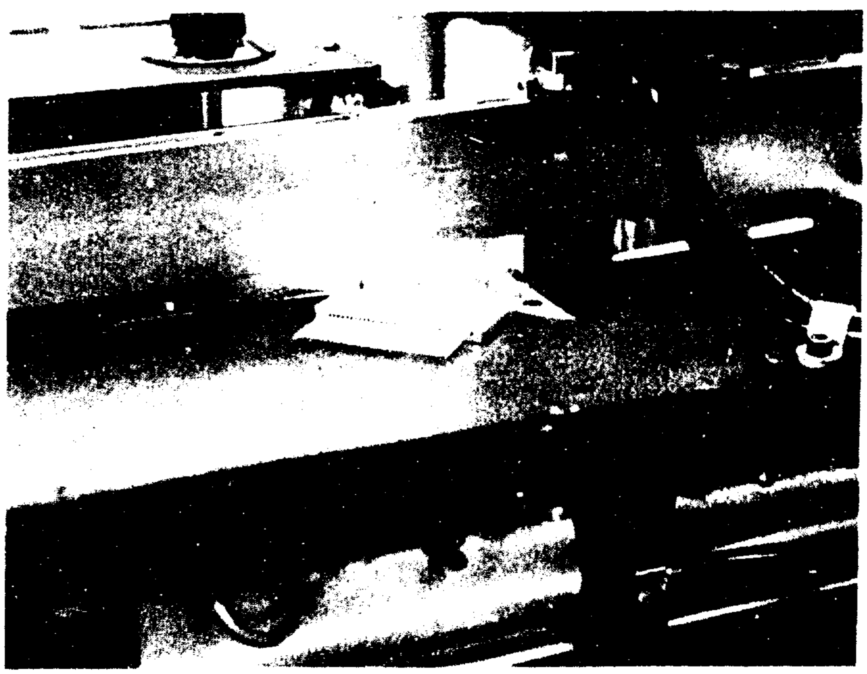


Figure 12. Cutting Corner At 45° Slant

## B. PROCESS DEVELOPMENT

Having refined the equipment, the next logical step was to refine the process itself in order to achieve optimum results. Process development included determining optimum parameter values and allowable tolerances, figuring out the best order for performing each step, and establishing the steps that are necessary in the first place in order to achieve best results.

Table VIII shows the impact of being under or over for several important criteria. In general, the emphasis, is on making a clean cut, machining away only the weld region and no more, preventing damage to the package header and circuitry,and making sure resealing will be successful.

Given the design of the saw blade and the blade mounting configuration, there is a practical limit to how much material the saw can remove before chattering. If the table feed rate is too high, contributing to excessive blade loading, the blade can't machine away the metal fast enough, and the balde stalls out, vibrates, chatters, and generally makes a much rougher cut than desirable. On the other hand, going very slow doesn't improve surface finish that much, and it wastes cycle time.

Table VIII. Impact of Process Variables

| | Impact | |
|---|---|---|
| Criteria | Too Little | Too Much |
| Table Feed Rate | Wastes Time | Poor Quality Cut |
| Saw Blade Loading | Wastes Time | Stall Blade, Poor Cut |
| Cut Depth | Lid Stays On | Cut Into Seal Flange |
| Cut Width | Lid Stays On | Lid Falls In, Blade Chatters |
| Cut Length | Lid Stays On | Wastes Time |
| Clamp Pressure | Package Held Insecurely | Damage Glass to Metal Seals |
| Step Height | N/A | Can't Reseal, Fails Leak Test |

Clamp pressure must be adequate to hole the package securely in the reference corner during each machining pass. Excessive pressure, however, tends to distort the package, cracking the glass to metal seals. This is particularly true for packages which start out warped, since the clamp will tend to flatten out the package. It is also required that the clamp pressure be low enough so that a given package can be clamped not just one time, gut many times. This margin of safety allows multiple delidding and resealing of each package.

Cut depth, width, and length must be adequate to entirely remove the weld region. It is undesirable to cut down into the seal flange, or to cut wider than the width of the wall and allow the lid to fall in. Wide cuts tend to be especially prone to chatter, so it is best to use a reasonably small cut width whenever feasible. Cutting too shallow or too narrow, on the other hand, leaves part of the weld behind and the lid stays in place. Setting the length of cut correctly serves two purposes. First, it determines how far the table will travel -- too short and some weld remains, too lont and time is wasted. Second, the pivoting clamp bar is automatically positioned over the package middle, centered between the ends. This provides uniform clamp force distribution.

A critical element of process development is minimizing step height. If the cut along a side of the package is too deep, the blade machines away part of the seal flange, creating a step from the original seal flange down to the machined surface. If the cuts down two adjacent package sides are not quite identical, a step occurs where the two cuts intersect. In a worst case, both types of steps can result at the same time.

Too high a step causes several problems for resealing. First, the welding electrodes will try to deform the lid over the step, introducing a bending stress and a potential crack zone along the ridge. Second, the weld energy distribution can be affected, particularly when the step configuration allows the electrode to pass current into both the seal flange edge and the step edge; this creates two marginal weld regions, and a probable leak site.

Too little step, however, is impossible. Zero step means that the machined portion of the seal flange is exactly level with the undisturbed portion. The only better situation is the virgin flange prior to sealing. It is desired to have no step, in order to maximize resealing success. In reality, some step may occur since packages are not perfectly flat and lid thickness is not exact. In order to cut through the lid at the thickest points ( and the lowest seal flange areas), it is necessary to overshoot a little where the lid is thin (and package seal flange in high).

The effect of step height on resealing is evident in figure 13. Resealing was performed on packages with known step heights in order to empirically determine the maximum allowable step. In the best case, where the cut was exactly the right depth and no step remained, almost 100% of the packages passed fine and gross leak test after resealing. Packages with no step resealed as effectively as packages which had virgin seal flanges. When the step was 2 mils high, leak test yield dropped to 90%. Steps of 4 mils interfered enough with resealing to decrease leak test yield to 50%. Packages with steps greater than or equal to the lid thickness exhibited only an occasional acceptable seal. Of course, steps this extreme should not occur during normal use; steps this extreme were purposely created in order to obtain more complete data.

Severe steps can occur in production, however, if the operator unknowingly dials in too wide or deep a cut. For example, if the operator thinks the package has a 10 mil lid when it has only a 5 mil lid, a 5 mil step will result. If the operator unknowingly cuts wider than the wall, and doesn't stop to examine the first two cuts before continuing, the lid will be pushed into the package when the clamp comes down; instead of the top of the lid being against the table top, the previously machined flange is, and the cut will be twice as deep as intended.

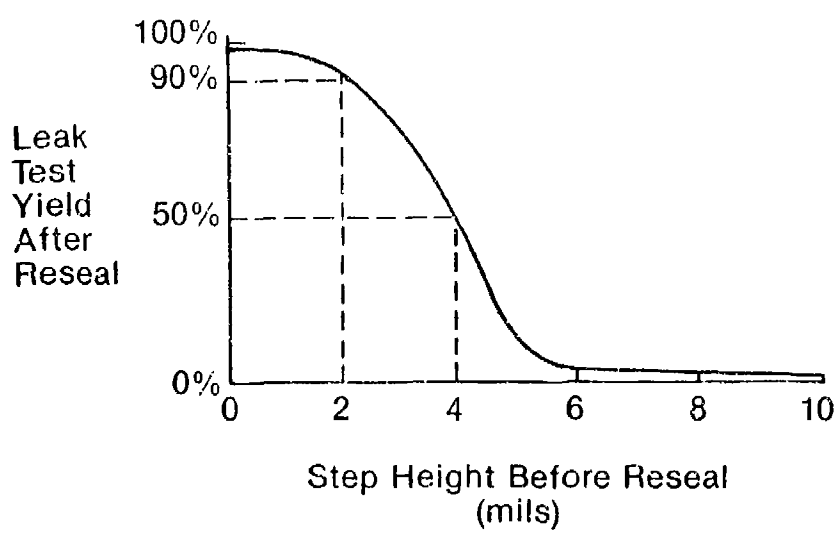



Figure 13. Step Height Impact On Reseal Yield

## C. OPTIMUM PARAMETER VALUES

By evaluating each of the variables in a manner similar to that just described for step height, the optimum parameter values were determined, along with the acceptable tolerances. Table IX presents the range evaluated and the value selected for each of the key variables in the delidding process.

Table feed rate was variable from 0-12 seconds per inch by adjusting a needle valve on the table's hydraulic dashpot. A speed of 7 seconds per inch provided acceptable throughput rates while maintaining adequate surface finish. Variations of $\pm$ 1 second per inch were acceptable. Saw blade speed is fixed by the design of the equipment at 75 revolutions per minute (rpm), and no need was found to change it or provide a variable speed of rotation. Other than to increase the rake angle to $10^{\circ}$, no need was found to change the design of the blade itself. High speed tool steel was chosen as the material in order to facilitate precision, true center grinding of the blade after mounting it on the spindle; this grinding reduces radial runout to less than 1 mil, and provides a true edge from which to measure the width of cut. The saw blade is 5 inches in diameter, 55 mils wide, and has 280 teeth around its perimeter. This combination of saw blade design, saw blade speed, and table speed results in an effective saw blade loading of 1/2 mil per tooth; this value is critical for effective machining of Kovar.

Table IX. Optimum Parameter Values

| Parameter | Range Evaluated | Value Selected |
|---|---|---|
| Table Feed Rate | 0-12 sec/inch | 7 sec/inch |
| Saw Blade Speed | (Fixed) | 75 rpm |
| Saw Blade | (Fixed) | 5-Inch Diameter, 280 Teeth, 10°Rake, 55 mils Wide |
| Cut Depth | 0-30 mils | Lid Thickness, Not to Exceed 10 mils/Pass |
| Cut Width | 0-55 mils | Wall Thickness — 10 mils |
| Cut Length | 0-3 Inch | Package Length |
| Clamp Pressure | 0-60 psig | 10 psig |
| Step Height | 0-10 mils | Not Exceeding 2 mils |

Optimum cut depth, width, and length are determined by the physical dimensions of the package being delidded. Useful guidelines, however, are possible. Cut depth is adjustable on the machine up to 20 mils, although deeper cuts were obtained by defeating the machine's built-in limiters. Kovar can be machined up to 10 mils in a single pass, which is more than the thickness of virtually all seam welded lids. Thicker lids can be removed by making a second pass all around the package after increasing the depth of cut the appropriate amount. Typically, welded lids are between 4 and 5 mils thick, and the cut depth should be set accordingly. It is worth noting that weld lids typically are specified with a $\pm$ 0.7 mil tolerance (instead of $\pm$ 1 mil or more) in order to know for sure ahead of time how deep to cut. The tighter the seal flange flatness is originally, and the smaller the tolerance on lid thickness, the less guesswork and inaccuracy will result during delidding.

Cut width must be less than the wall thickness, as already explained. The rule of thumb is to set the cut width to 10 mils less than the wall thickness. Typically, the packages have walls 40 mils thick, and the welds are 20-30 mils wide depending on weld equipment and parameters. In this situation, the cut should be 30 mils wide in order to completely remove the weld. If absolutely necessary, it is sometimes possible to cut within 5 mils of the wall thickness, but package tolerances and placement accuracy can result in too wide cuts. Exceptions can be made under certain conditions. For example, if one side of the package was touched up and now has a wider weld (even up to the entire wall thickness), cut the other three sides normally, then temporarily set the cut width enough to remove the entire width before making the final pass (remember to reset the width back to 30 mils before delidding the next package).

Cut length is not a critical setting, and can be accomplished by dialing the length on the package size knob, or by visually lining up the red mark in the center of the clamp bar over the approximate package center. Positioning to eyeball accuracy is all that is necessary. Packages up to 3 inches on a side may be delidded in a straightforward manner, while larger packages require some innovation.

Clamp pressure is slightly dependent on package size, with larger packages requiring more pressure than smaller ones. Packages in the 1-2 inch range will be easily restrained by 10-15 pounds per square inch (psig) pressure as indicated on the clamp pressure gauge. Extremely small packages may require less pressure to prevent glass damage, while very large packages may need more pressure in order to maintain adequate friction between the package and the clamp and table surface. In general, it is desirable to minimize clamp pressure to prevent possible damage to the glass seals, so 10 psig is the recommended value for a 1" x 2" package.

Step height has already been discussed at length, with the optimum step height being 0 (zero) mils, and the maximum recommended step 2 mils in height. Less than zero mils step means that part of the lid is still attached. If the lid is still attached all around the seal flange, the cut depth needs to be increased; if only one spot is still attached, the lid will hang from that area instead of falling off. In the latter situation, flex the lid back and forth until it breaks off, then carefully dress any burrs on the flange with a knife. It is not necessary to whittle the lid away until the flange is reached; the seal flange probably wasn't flat before and the saw missed the low spot. Resealing will be easier with the lid remnant helping provide a flat surface for welding.

Resealing parameters are not listed in Table IX, since they vary according to what the hybrid manufacturer has determined is best for sealing the package originally. While this delidding method achieves excellent particle control, a thorough cleaning is recommended prior to sealing in order to remove particles and contamination that may have entered the package sometime during the rework operations. Resealing is performed using a new lid (the old lid has been partly machined away), and using the identical equipment and welder settings as for normal sealing. This feature allows resealing to be performed in harmony with normal sealing operations. Routing, handling, and processing are all identical during these operations, minimizing the disturbing influence of rework on standard production processing.

## VI. QUALIFICATION TESTING

### A. GENERAL

In order to prove that the delidding and resealing techniques developed were truly effective, and that the circuit performance was not degraded, a rigorous qualification test was conducted. Fully functional hybrid circuits were utilized to ensure applicability for real world systems. Most of the packages were delidded and resealed, while some served as control packages and were not delidded. All of the packages were subjected to Mil-Std-883 requirements for Class B hybrids, including electrical, mechanical, and environmental tests. Electrical, fine and gross leak, and PIND tests were highlighted.

### B. HYBRID CIRCUIT AND PACKAGE

A computer programmer hybrid, currently in use in an electronic countermeasures system, was selected (figure 14). Twenty-six thick film resistors were screened onto the multilayer substrate, and laser trimmed. Nine silicon integrated circuit chips and two chip capacitors were epoxy mounted onto the substrate, and interconnected with almost two hundred 1 mil gold wires. Each substrate was epoxy mounted into a 1" x 2" gold plated Kovar butterfly package, which was subsequently seam welded (figure 15) with a gold plated etched step lid.

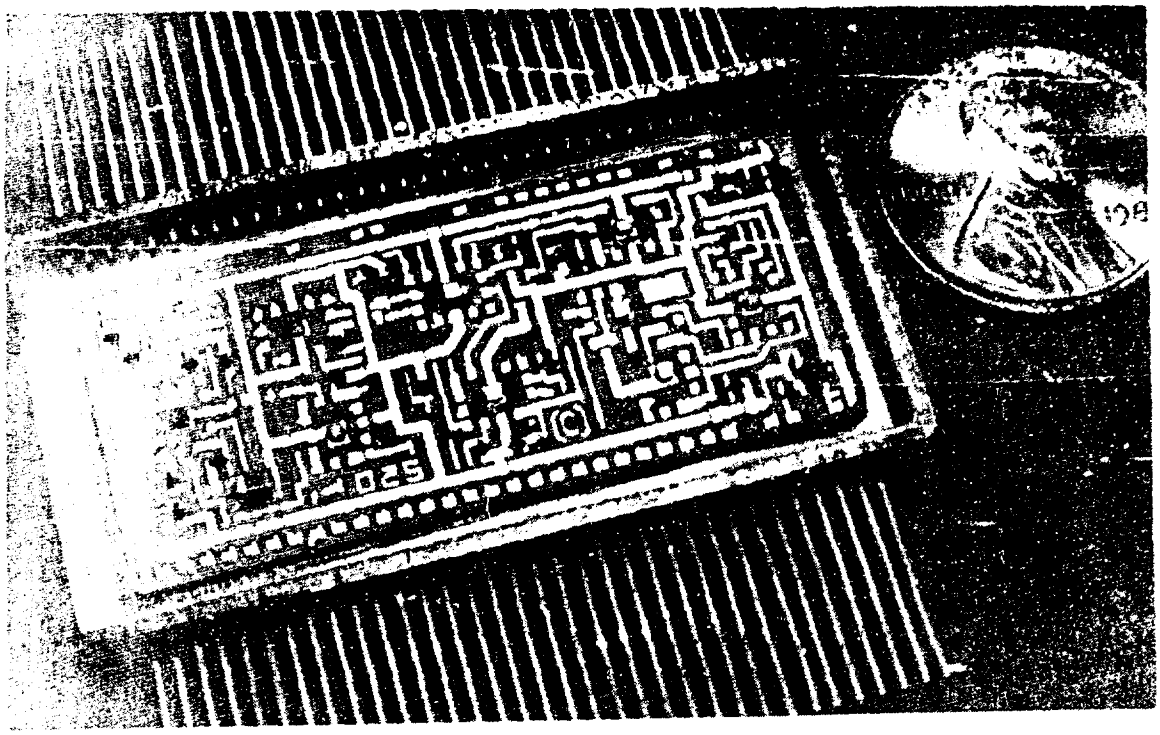


Figure 14. Hybrid Circuit Used In Qualification Test

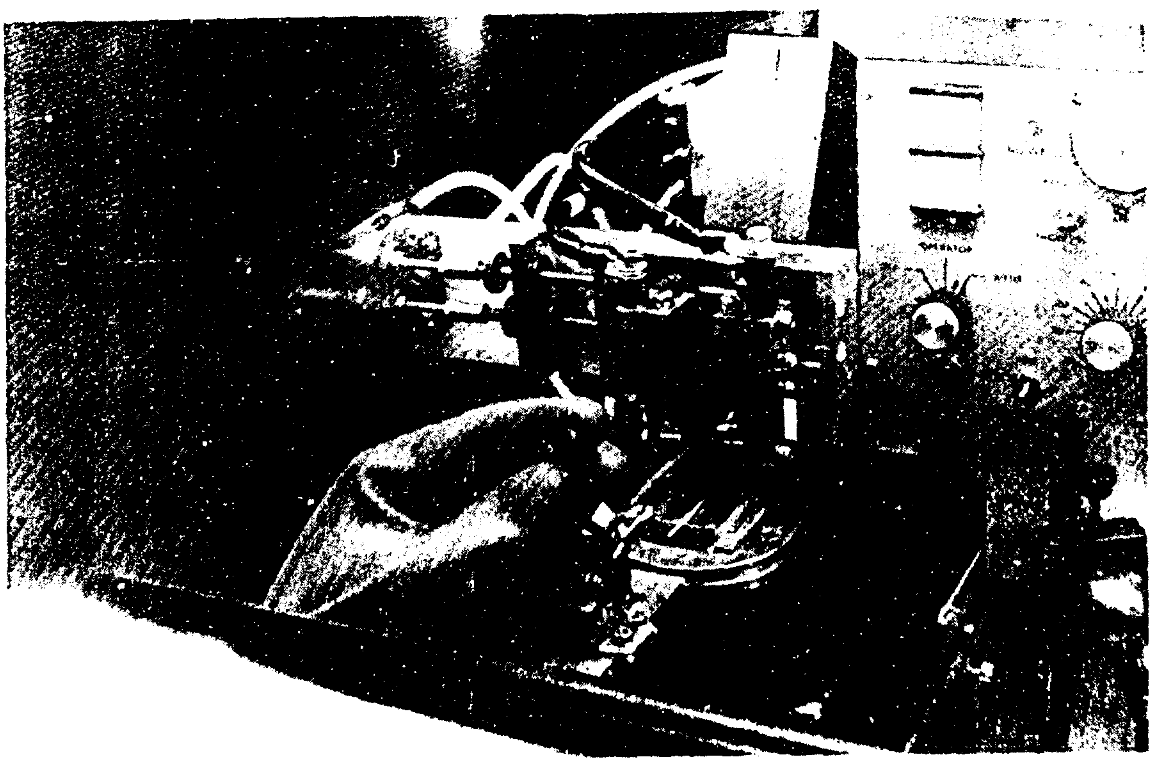


Figure 15. Parallel Seam Welder

C. TEST SEQUENCE

A step by step test sequence flow chart is presented in figure 16. Each test was conducted in accordance with the Mil-Std-883 method listed in the text below. Eighty-eight functional hybrids were built, divided equally between packages from two vendors.

Electrical testing was performed per method 5008, screening all applicable circuit parameters. Each hybrid was given an internal visual examination per method 2017.1. Thorough cleaning preceded a one hour minimum vacuum bake out at 125$^{o}$C, and sealing on a parallel seam welder. Fine and gross leak tests were performed per method 1014.4, conditions Al and C, respectively. Subsequent to a 4 hour bombing at 30 psig of Helium, the packages were required to meet a measured leak rate limit of 1.0 x $10^{-7}$ standard atmosphere cubic centimeters per second. Fluorocarbon bombing, prior to immersion in the 125$^{o}$C fluorocarbon, was not performed as part of the gross leak test. Particle impact noise detection (PIND) testing was conducted per method 2020.2, condition B (40 Hz, 0.06-0.10 inch amplitude, 5 G's). Another electrical test and an external visual per method 2009.2 completed the initial set of screening tests. Of particular interest was the condition of the glass to metal seals, which were examined to the ISHM (International Society for Hybrid Microelectronics) standards.

Of the 88 hybrids built and screened as above, 22 were not delidded, but served as control control packages, providing a reference point. The remaining 66 were delidded using the equipment and process developed. Another internal visual examination was conducted, emphasizing particles and package damage such as cracks in the glass seals. An electrical test was performed to ensure delidding had not affected the circuit performance. Each of the delidded packages was then cleaned and resealed on the same welder as originally, using the same welder parameters. Fine and gross leak tests sought to verify the integrity of the reworked weld joint. PIND and electrical test were performed to verify the circuit was still clean and functional inside the package.

All 88 packages were then subjected to a series of environmental tests. Stabilization bake was performed per method 1008.1, condition B, which calls for 125$^{o}$C for 7 days in air. Fine and gross leak tests were performed here, and after each of the following environmental tests. Temperature cycling per method 1010.4, condition B stressed the packages in air between -55 to +125$^{o}$C through ten complete cycles. Thermal shock per method 1011.3, condition B, subjected the packages to fifteen cycles between liquids at -0 and +100$^{o}$C. Constant acceleration, or centrifuge, was done per method 2001.2, condition A; the Y1 axis, which tends to pull the substrate up from the package, was used at a level of 5,000 G's. Mechanical shock test was performed per method 2002.1, condition B; the Y1 axis was used in this test, also, subjecting each package to 5 cycles at 1500 G's peak level, with a pulse duration of 0.5 milliseconds. Fine and gross leak, PIND, and electrical tests were repeated to substantiate the hybrid's integrity and performance after the environmental tests.

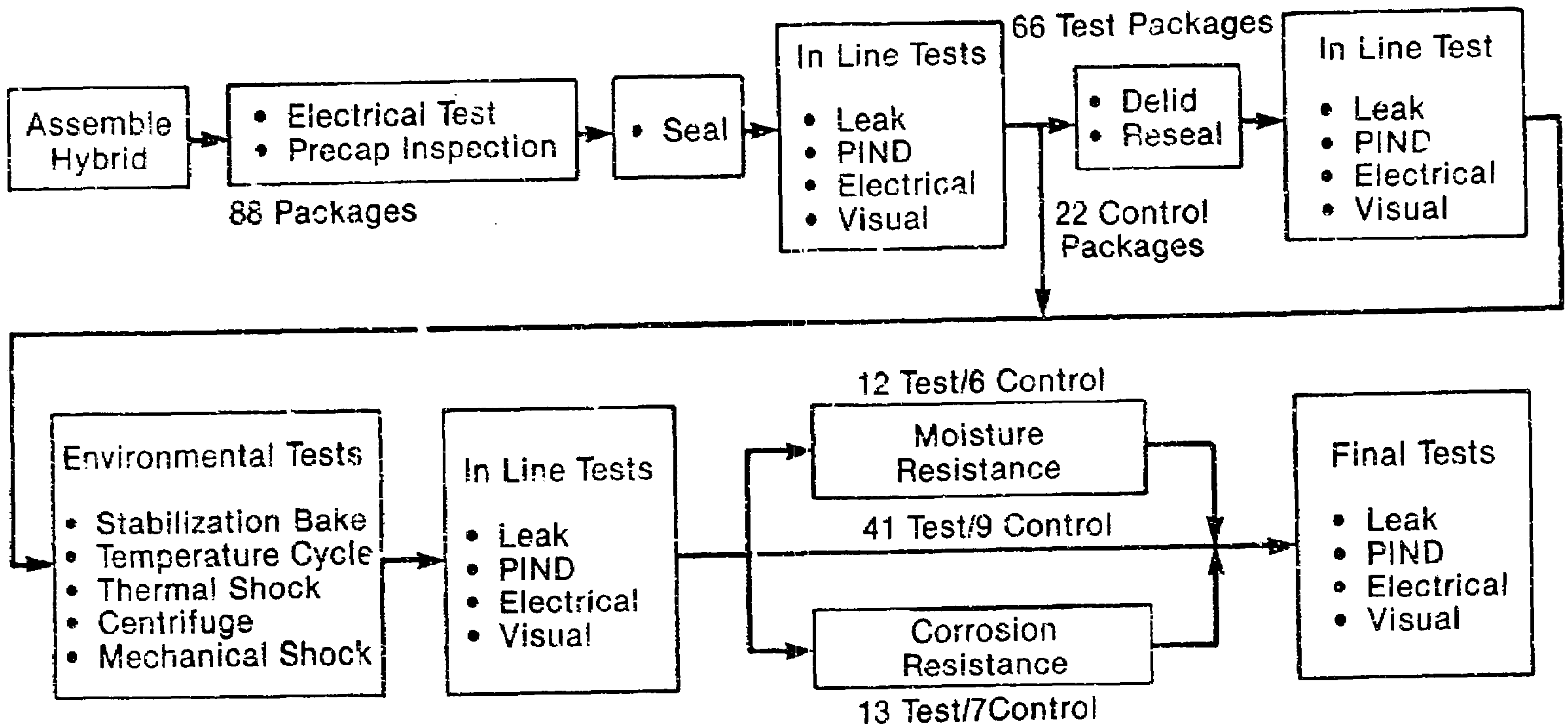



Figure 16. Qualification Test Sequence

As further proof of the reliability of the resealed packages, sev ral destructive tests were performed. Moisture resistance, or humidity test, was performed per method 1004.3, subjecting a sampling of packages to 10 cycles of 90% relative humidity, between 25 and 65°C; a +15 volts DC bias was applied to alternate leads, with the remaining leads connected to ground. In conjunction with the moisture resistance test, insulation resistance testing was performed per method 1003, with a +15 volts DC potential. Another sampling of packages were given the salt atmosphere, or corrosion resistance, test per method 1009.3, method A; this condition requires exposure to a salt atmosphere fog at 35°C for 24 hours, where the rate of salt deposit on the test area is between 10,000 and 50,000 milligrams per square meter per day. Each package undergoing these severe tests was then subjected to another round of fine and gross leak, PIND, and electrical tests. Another visual exam finished the test sequence. Additional testing was to be performed as deemed necessary during the qualification test sequence.

## D. TEST RESULTS

Results of the Qualification Test were extremely favorable. Virtually no failures were encountered, and when they did, the control group and resealed group performed equally. Individual package data is presented in Appendix B. Table X shows the results in a summarized form. Composite yields are tabulated, showing the percentage of packages which passed that test every single time; this will be more clearly explained in the comments on PIND test results.

Table X. Qualification Test Results

| Test Description | Composite Yield | |
|---|---|---|
| | Test Packages | Control Packages |
| F&G Leak* | 100% | 100% |
| PIND | 94% | 95% |
| Electrical** | 100% | 100% |
| Environmental | 100% | 100% |

*All Packages ≤ 1.0 × $10^{-7}$ cc/sec Helium
**No Significant Shift in Electrical Parameters

Fine and gross leaks tests were performed 8 times during the course of the Qualification Test, but no failures were observed; the test (delidded and resealed) and control (no delid) groups both ehxibited 100% yields. None of the packages failed electrical test any of the five times it was performed; all of the hybrids showed consistent performance in all critical parameters.

PIND test yields were essentially identical for the two groups, with 94% and 95%, respectively. The fact that 100% yields were not achieved is not too surprising; PIND test is a sensitive and controversial test, and perfect yields are extremely difficult to achieve unless the equipment's sensitivity is low. The 94% and 95% yields were composite yields for all of the PIND tests combined; individual test yields were typically 97% and 100% for resealed and control packages, respectivley. Since PIND failures do not have to be repeatable, each package failing any one test is a reject. In reality, none of the packages failed all three times, and only three test packages failed more than once; one control package and two test packages failed PIND test once during the Qualification Test, and could not be made to fail during subsequent attempts. Further, X-Ray examination showed only one of these packages contained a loose particle; the particle could not be traced to the delidding operation. This is part of the reason that PIND testing is not favored by manufacturers, except possibly for the most critical applications.

Environmental testing went well, also, with only one problem. When the packages were wired for moisture resistance testing, with alternate leads at ground and +15 VDC bias, the small signal logic circuitry was destroyed by the bias voltage and eventually loaded down the power supplies. This made it impossible to maintain the bias, so half of the test duration was without a potential on the packages. Subsequent electrical tests on these particular packages was useless, since the circuitry had been wiped out. Otherwise, the packages passed these tests, without developing leaks, lifted components or substrates, or excessive corrosion. Excluding the wiring problem, all of the packages exhibited a 100% yield through the environmental portion of this Qualification Test.

Visual examination of the weld joints and glass seals showed no rejectable damage, such as radial cracks originating at the package body. There was no significant difference between packages from the two different vendors, since there was no significant degradation. Cross-sections of the weld joints showed good, void-free welds for initial seals, reseals, and even a second reseal (figures 17-19).

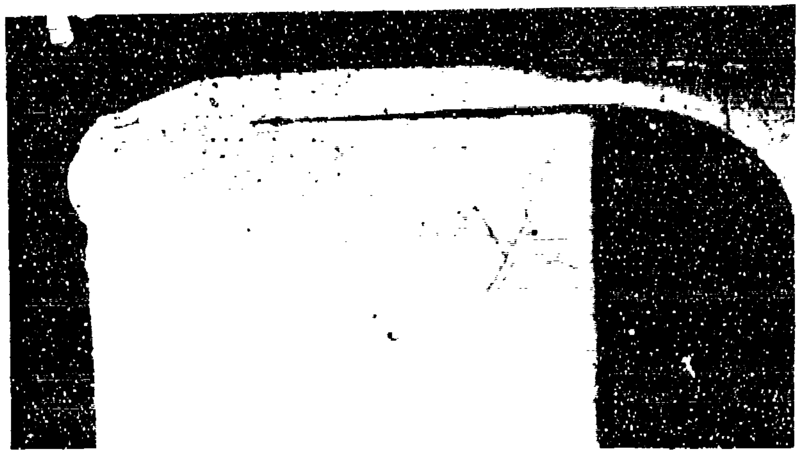


Figure 17. Cross-section of Welded Package

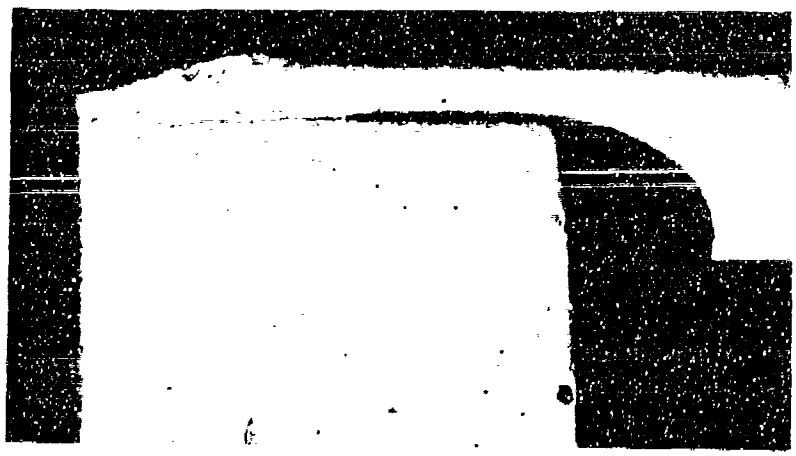


Figure 18. Cross-section of Resealed Package

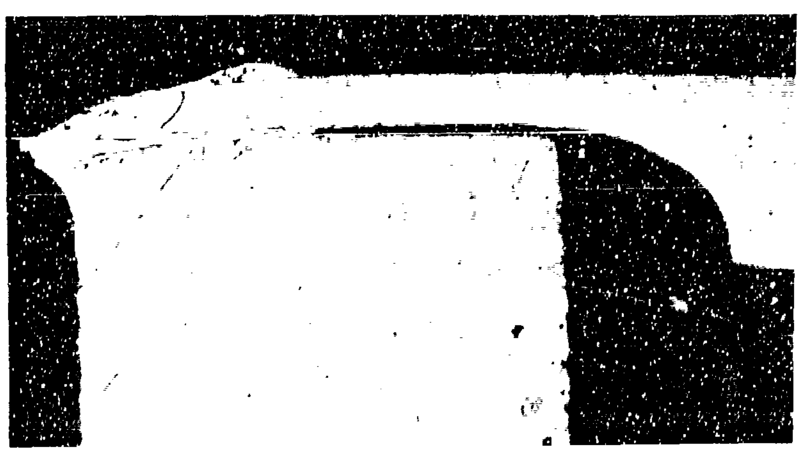


Figure 19. Cross-section After Second Reseal

## E. ANALYSIS

Analysis of data is straightforward when the data is as consistent as that obtained during this Qualification Test. Leak testing, PIND testing, electrical testing, and environmental testing showed no significant difference between packages which had been sealed only once and packages which had been delidded and resealed with the method developed herein. Weld quality and integrity was equally good for original seals and reseals. All of the packages performed at least as well as the minimum required for Class B hybrids, with the exception of isolated PIND failures. Delidding and resealing, as conducted, has been proven to be effective as a rework method without degrading the package or circuit reliability.

# VII. ADDITIONAL EFFORTS

## A. MULTIPLE RESEALS

Qualification testing was done only on packages which had not been delidded, or had been delidded and resealed once. During the development effort, however, some packages were delidded and resealed several times. This was done partly to investigate the cumulative effect of machining errors and imperfections, and partly to see how many time a hermetic seal could be achieved on a single package. An example of a multiple reseal was included earlier with the weld cross-sections.

Machining anomalies, whether they be due to the package being warped, the machine being out of adjustment, or to the operator not doing something quite right, create a practical limit on how many times a package can be delidded and resealed in a normal production environment. One reseal is not difficult to achieve; two reseals are possible; three reseals requires the operators to be paying attention to what goes on each time. In an engineering environment, such as in a prototype laboratory, additional reseals can be achieved if proper care is taken each time. This is particularly true if the package is designed with the glass seals well away from the weld flange, and if the package has enough internal clearance to allow loss of a few thousandths of an inch wall height, if necessary.

## B. OTHER PACKAGE CONFIGURATIONS

Limited testing was conducted on welded package configurations in addition to the butterfly package. Specialized packages bearing some resemblance to butterfly packages were delidded and resealed, as were nonrectangular butterfly packages and bottom-pin bathtub packages. Each of these package configurations was tested only for delid/reseal feasibility; full qualification testing was not performed. Figure 20 shows several specialty packages which were effectively delidded and resealed. The smaller packages were welded microwave packages; the smallest was approximately 1/4 by 3/8 inch.

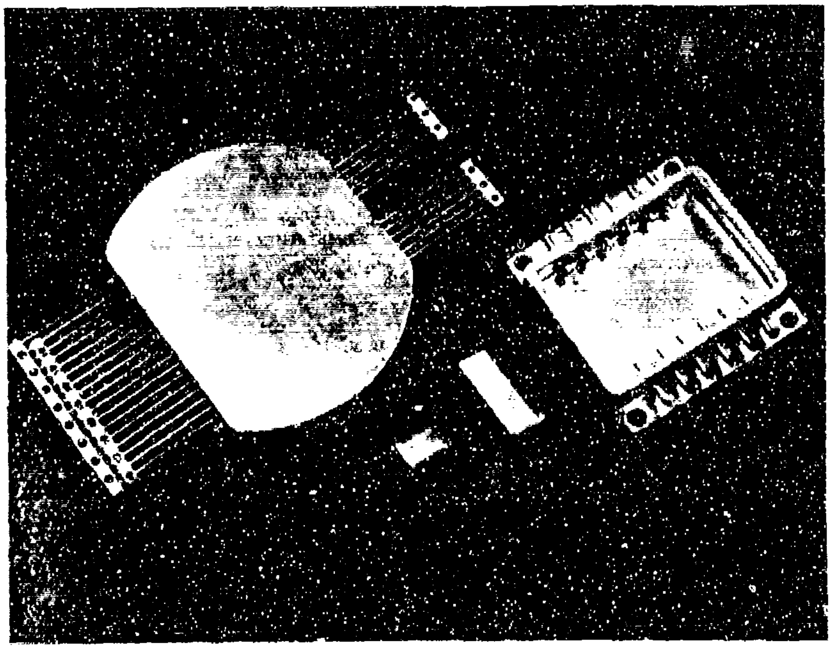


Figure 20. Specialty Packages Delidded and Resealed

Westinghouse and several other companies use a large copper package design for high power applications. Although the package has several times the internal volume of a 1" x 2" butterfly package, the package does have leads only through the sidewalls. The packages are welded on the top of the wall, which serves as the sealing flange. Various techniques are used to achieve a weldable seal flange, since copper cannot be resistance welded on the hybrid sealers available; the package shown has a Kovar ring brazed onto the wall.

Delidding of this configuration was almost the same as a standard butterfly package, although two deviations were necessary for some designs. First, the lid may be twice as thick as on a smaller package, requiring a deeper cut; this was still within the capability of the delidding machine. Second, some of the packages had large corner radii, which the weld followed. Since the saw blade could only cut a straight path, it was possible for the radius to be large enough that the blade missed the inside part of the weld in the package corners. In this case, the package was placed at a $45^{\circ}$ angle, as described in the equipment development section. Resealing of these packages seemed to be as effective as resealing conventional butterfly packages.

At the time of this report, one of the other vendors for hybrids in these packages had begun using the method developed on this contract, with one variation. In order to avoid making the extra cuts in the corners, a double-width blade was used. taking advantage of the 0.090" wide walls typically found on these packages; the wider blade made a wider path down each side of the package, achieving the necessary overlap in the corners. Making cuts this wide, however, did increase the probability for chatter and excessive machining noise.

Another specialty package evaluated was a planar lead package resembling a truncated circle (figure 20). This unusual shape package provided a test for the repeatability of cut depth over many cuts, since it was necessary to approximate the curve with a series of straight cuts. The straight wall segments required one cutting pass each, while the curved segments required five or six passes, depending on how accurately the operator rotated the package between cuts. A specially modified sealer was used to seal the packages originally, but resealing was accomplished on the same welder as was used for the contract packages; a series of straight weld passes was required, much the same as for delidding. Fine and gross leak test results, on a very restricted sample size, were an order of magnitude better than required by Mil-Std-883. Delidding completely round packages could be facilitated by replacing the linear table feed with a rotary table, although some equipment redesign would be necessary. Combining rotary and linear feed in the same table would require a major equipment modification, and was not pursued.

Bottom-pin bathtub or plug-in packages were also delidded and resealed. Use of an adaptor fixture was necessary at first, until the clamp bar was redesigned to include slots on 0.100" centers. These slots were spaced to accommodate most of the bathtub packages being used today; if a particular package had a different pin spacing or had stand-offs which interfered with the clamp, an adaptor fixture could easily be made and used. The only other complicating factor was that some of these packages had large corner radii, and must be handled in the same fashion as the power packages above. Both of these approaches were found to provide completely satisfactory delidding results. Resealing, again, was straightforward, and produced good leak test results.

## C. SOLDERED PACKAGES

While the delidding approach developed was intended only for welded packages, some attention was given to soldered packages. Since the delidding operation typically resulted in bare Kovar being exposed, fluxless soldering would be virtually impossible for resealing. If the complete solder joint were removed, however, the resultant exposed Kovar seal flange could be weld sealed. Soldered bathtub packages were used to investigate this, although butterfly packages could have been used just as appropriately.

It was desired to completely remove all solder from the seal flange area in order to prevent solder from splashing or interfering with welding. To accomplish this, it was necessary to machine the entire width of the package wall. In fact, it was necessary to machine more than this width, in order to remove the solder fillet on the inside package wall. Doing this precluded using the top of the lid as the reference plane for all but the first two cuts.

A solution was found in using metal shim stock the same thickness as the depth of cut being made. First, the two long sides of the package were machined along their entire length, and as wide as the blade would allow. Then the shim stock, which were attached to a U-shaped plate which kept the stock spaced properly (figure 21), were positioned under the machined walls. The shim stock acted as a surrogate lid, keeping the package the proper distance above the saw blade while a short side was cut; rotating the package in the spacer tool allowed the final side to be cut accurately, too.

Since there was enough clearance inside the package to sacrifice a little more wall height, another complete machining pass was made to help remove all of the solder fillet; the spacer was used for the last two cuts, as before. One complication with performing the second cutting pass was that the circuit was exposed, and could collect some machining particles since the particle control designs had been partially defeated.

Resealing using a welder resulted in good leak test yields for this technique, also. It should be noted, however, that this approach was developed as a special rework technique for use on prototype hybrids, and was not intended for daily production use.

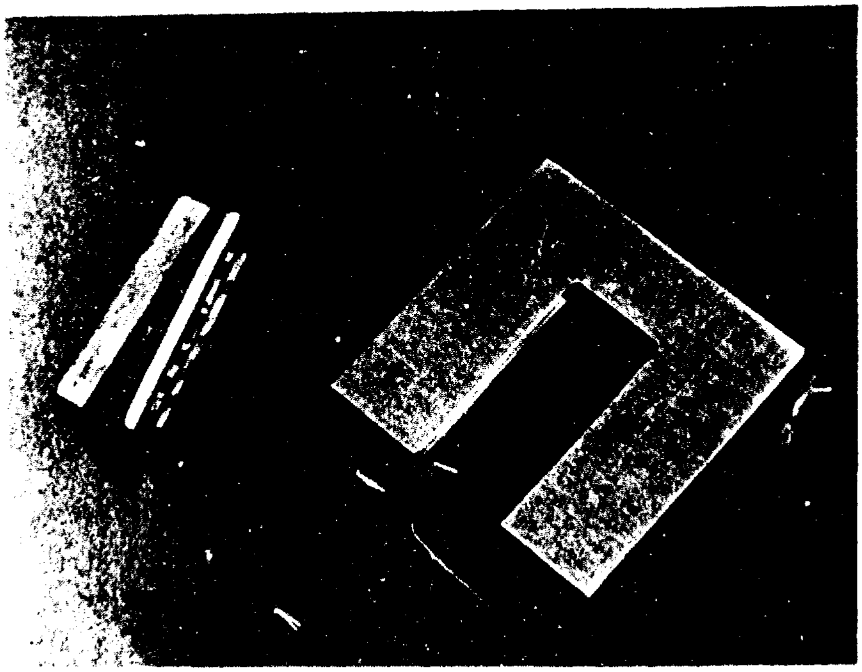


Figure 21. Shim Stock Spacer Fixture

## VIII. IMPLEMENTATION

Several factors govern how readily a process is implemented. First, the process needs to be established, defined, and proven; this contract has satisfied each of these - the Process Specification is attached as Appendix C, and the qualification testing proved the technique works. Second, the equipment has to be available; the equipment manufacturer has already increased production in response to the growing number of inquiries stemming from this MM&T contract. Third, the method has to be easy enough for any operator to perform it adequately; it is. Fourth, the cost to acquire and install the equipment must be reasonable; the $10K purchase price of the SP112 and negligible installation cost are easily amortized in a production run, or in a laboratory environment where quantities are lower but hybrid costs are higher. Fifth, the process must be accepted by the industry; the favorable response evident to Westinghouse, Sharp Precision, and to the Army and Navy sponsors seems to indicate that the sometimes fatal curse of NIH (not invented here) is being overshadowed by the obvious and substantial benefits to be accrued by implementing this technology.

When manufacturing hybrids for Military applications, it is necessary to have more than just industry acceptance; the appropriate Military specifications must allow the procedure. This is the only major obstacle remaining in the path of widespread implementation of the delidding and resealing technique developed under this contract. Westinghouse has proven out the technique to their own satisfaction, and to the satisfaction of many other companies. Both the Army and the Navy sponsors have expressed their satisfaction, also. Westinghouse has been keeping the cognizant Government agency notified of progress on this contract, and the intent to petition for approval of this delid/reseal method. With the release of this report, a formal petition will be filed. Supporting evidence will be collected and submitted, as other companies implement this technology by waiver.

Internally, Westinghouse has implemented this technology on all applicable programs, again, by waiver. New hybrid designs are increasingly utilizing package configurations which can be delidded and resealed per this method. One entire line of specially designed packages which are now solder sealed has been modified to enable welding, allowing delid/reseal as necessary per the method developed. Use of soldered ceramic butterfly packages will decline in order to take advantage of the delid/reseal capability afforded by welded metal butterfly packages via the technique herein.

## IX. CONCLUSIONS

Delidding and resealing is becoming increasingly important as a rework technique. Delidding and resealing involves removing the lid from a sealed hybrid, repairing the circuit, and resealing the same package with a new lid. This rework method offers a tremendous potential for savings in the labor and materials costs of manufacturing hybrid microelectronic packages, without incurring any degradation of the microcircuit. Delidding and resealing also provides a faster rework, reducing the impact of rework on regular production, and helping to meet production schedules. It is thus of interest to both manufacturers and users.

Survey data showed welded metal butterfly and bathtub packages to be the most commonly used packages for Military applications. End milling and precision sawing were the most common delidding techniques, with sawing being favored for further development. Survey responses indicate savings due to delidding and resealing are presently $2.5 million per year, and could exceed $10 million annually if a successful delid/reseal method received widespread implementation.

Sawing equipment and processes were developed and refined to accommodate both welded butterfly and bathtub packages. The equipment is now available from Sharp Precision as their Model SP112 Microcircuit Cover Remover. The SP112 is a self-contained benchtop machine which is fast, easy to use, safe, and versatile enough to delid a variety of package styles. Appendix C to this report is the process specification for using this machine, including the optimum process parameters and acceptable tolerances. Qualification testing was conducted to Mil-Std-883 requirements, and proved the technique developed is effective and reliable, and that hybrid performance is not degraded.

Implementation has occurred at Westinghouse, and is underway at other companies. Full scale implementation will be enhanced if the effort to amend Mil-M-38510 to allow delid/reseal per the method herein is successful within a reasonable time span.

## X. APPENDICES

A. SURVEY QUESTIONNAIRE

B. QUALIFICATION TEST DATA

C. PROCESS SPECIFICATION

APPENDIX A.

SURVEY QUESTIONNAIRE

DELIDDING AND RESEALING

HYBRID MICROELECTRONIC PACKAGES (TR#0048)

Prepared under Contract Number DAAH01-80-C-0435
for the United States Army Missile Command,
Redstone Arsenal, Alabama 35809

Westinghouse Electric Corporation
Defense and Electronic Systems Center
Baltimore, Maryland 21203

# INTRODUCTION

Westinghouse has been awarded a Manufacturing Methods and Technology Contract to establish the manufacturing technology necessary for delidding and resealing hybrid microelectronic packages. Your participation in this survey will help to develop a widely acceptable technology for reducing the manufacturing cost of hybrids. It is anticipated that military specifications will be amended to allow at least limited reworking of sealed packages.

The purpose of this survey is to establish baseline data concerning hermetically sealed hybrid microelectronic packages. Please limit your responses to hybrids which meet MIL-STD-38510 requirements, or equivalent. Of particular interest are multi-chip hybrids utilizing planar lead or bottom pin packages three-quarters of an inch square and larger. Any information you provide will be treated as proprietary; nothing will be published or disclosed that would enable tracing any of your answers back to you.

We are asking you to provide data regarding:

I. Types and sizes of packages in use, or planned.

II. Respective quantities used.

III. Yield and cost information pertaining to delidding and resealing activities.

IV. Delid/Reseal experience and recommendations.

Respondents will receive the results of this survey, and will be invited to the industry demonstration at the conclusion of the contract (Sept. 1981).

# INSTRUCTIONS

Please fill in all information that is applicable to your products. Use your best judgement where necessary. Please consider giving a range of values for any question for which you may hesitate to provide a specific answer. If you should choose not to answer certain questions, for any reason, please return the partially completed questionnaire, as it still will be very useful.

For assistance in completing this questionnaire, contact one of the following:

| | |
|---|---|
| Gene DiGennaro | (301) 765-2828 |
| Wyatt Luce | (301) 765-2828 |
| Louis Razzetti | (301) 765-4778 |

A stamped envelope has been provided for returning the questionnaire. It is addressed to:

Westinghouse Electric Corporation
Defense & Electronic Systems Center
Systems Development Division
P. O. Box 746
Baltimore, Maryland 21203

ATTN: Louis Razzetti, MS/V-14

## RESPONDING COMPANY INFORMATION

Name of Company ______________________________

Division ______________________________

Department ______________________________

Mail Code ______________________________

Address ______________________________

______________________________

______________________________

Name of respondent ______________________________

Position ______________________________

Telephone ____( )__________________ Extension __________

Principal products ______________________________

Products utilizing hybrid microelectronic packages ______________

______________________________

Approximate annual volume of hybrid packages ($/yr.)? ______________

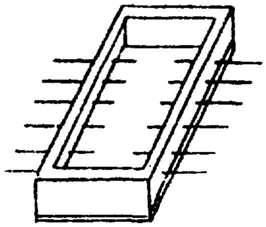
What percentage of these are used in Tri-Services missiles and avionics equipment? ______________________________

## PACKAGES

Match the packages you use to the nearest approximate size in the following five tables. Other sizes may be included in the extra spaces provided. For each package configuration, fill in the quantities of each package finish used monthly, the percentages soldered and welded, and the average finished cost for the hybrid.

TABLE 1: METAL PLANAR LEAD FLATPACKS

| APPRROXIMATE SIZE | QUANTITY PER MONTH | | | SEAL METHOD | | AVERAGE FINISHED COST |
|---|---|---|---|---|---|---|
| | GOLD FINISH | NICKEL FINISH | OTHER (SPECIFY) | WELD (%) | SOLDER (%) | ($/HYBRID) |
| 3/4"x3/4" | | | | | | |
| 1"x1" | | | | | | |
| 1"x2" | | | | | | |
| 2"x2" | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |



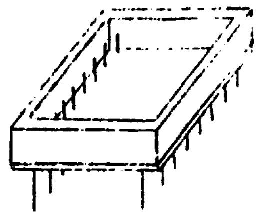
Expected package trends (sizes, finishes, sealing methods)?

1985: ____________________

1990: ____________________

TABLE 2: METAL BOTTOM PIN PACKAGES WITH SIDEWALLS

| APPRROXIMATE SIZE | QUANTITY PER MONTH | | | SEAL METHOD | | AVERAGE FINISHED COST |
|---|---|---|---|---|---|---|
| | GOLD FINISH | NICKEL FINISH | OTHER (SPECIFY) | WELD (%) | SOLDER (%) | ($/HYBRID) |
| 3/4"x3/4" | | | | | | |
| 1"x1" | | | | | | |
| 1"x2" | | | | | | |
| 2"x2" | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |



Expected package trends (sizes, finishes, sealing methods)?

1985: ______________________________

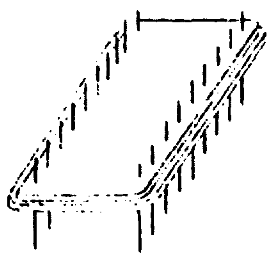
______________________________

1990: ______________________________

______________________________

TABLE 3: METAL BOTTOM PIN PACKAGES WITHOUT SIDEWALLS

| APPRROXIMATE SIZE | QUANTITY PER MONTH | | | SEAL METHOD | | AVERAGE FINISHED COST |
|---|---|---|---|---|---|---|
| | GOLD FINISH | NICKEL FINISH | OTHER (SPECIFY) | WELD (%) | SOLDER (%) | ($/HYBRID) |
| 3/4"x3/4" | | | | | | |
| 1"x1" | | | | | | |
| 1"x2" | | | | | | |
| 2"x2" | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |



Expected package trends (sizes, finishes, sealing methods)?

1985: ______________________________

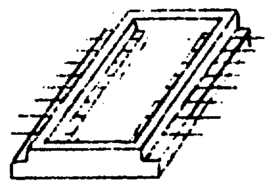
______________________________

1990: ______________________________

______________________________

TABLE 4: CERAMIC PLANAR LEAD FLATPACKS

| APPRROXIMATE SIZE | QUANTITY PER MONTH | | | SEAL METHOD | | AVERAGE FINISHED COST |
|---|---|---|---|---|---|---|
| | GOLD FINISH | NICKEL FINISH | OTHER (SPECIFY) | WELD (%) | SOLDER (%) | ($/HYBRID) |
| 3/4"x3/4" | | | | | | |
| 1"x1" | | | | | | |
| 1"x2" | | | | | | |
| 2"x2" | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |



Expected package trends (sizes, finishes, sealing methods)?

1985: ____________________

____________________

1990: ____________________

____________________

TABLE 5: OTHER PACKAGE TYPES

This category is for packages such as large ceramic chip carriers (used with a substrate inside), integral substrate packages, high power hybrid packages, etc. Give a brief description and a sketch of any such packages you use commonly.

TYPE I ____________

TYPE II ____________

TYPE III ____________

TYPE IV ____________

TABLE 5: cont.

| APPROXIMATE SIZE | PACKAGE TYPE (I-IV) | QUANTITY PER MONTH GOLD FINISH | NICKEL FINISH | OTHER (SPECIFY) | SEAL METHOD WELD (%) | SOLDER (%) | AVERAGE FINISHED COST ($/HYBRID) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Expected package trends (sizes, finishes, sealing methods)?

1985: ______________________________

______________________________

1990: ______________________________

______________________________

# HERMETIC SEALING

1). Indicate the percentage of packages sealed by each of the following:

_________% One-shot Resistance Weld

_________% Parallel Seam Weld

_________% Laser Weld

_________% Other Weld (describe) ______________________________

_________% Manual Soldering

_________% Furnace Soldering ("Brazing")

_________% Infrared Soldering

_________% Heated Platen Soldering

_________% Other Solder (describe) ______________________________

_________% Other methods (describe) ______________________________

2). Sealing equipment utilized?

- ☐ Superior Welder Inc. Parallel Seam Welder
- ☐ Solid State Equipment Corporation Parallel Seam Welder
- ☐ Other Welders (specify) ______________________________

- ☐ Research Instruments Corporation Solder Sealer
- ☐ GTI Incorporated Solder Sealer
- ☐ Other Solder Sealers (specify) ______________________________
- ☐ Other Equipment (specify) ______________________________

## REWORK

Tables 1-5). Fill in the monthly quantity of each package configuration which is subjected to the following rework operations:

A). Delidded to allow circuit repair and subsequent resealing of the same package.

B). Delidded to allow circuit repair and/or scrapping faulty package, and subsequent resealing of substrate in new package.

C). Scrapped without attempting to delid package and repair circuit or replace package.

TABLE 1: METAL PLANAR LEAD FLATPACKS

| | A. DELID/RESEAL | | B. DELID/REPACKAGE | | C. SCRAP/NO DELID | |
|---|---|---|---|---|---|---|
| Approximate Size | Welded (Qty/Mo) | Soldered (Qty/Mo) | Welded (Qty/Mo) | Soldered (Qty/Mo) | Welded (Qty/Mo) | Soldered (Qty/Mo) |
| 3/4"x3/4" | | | | | | |
| 1"x1" | | | | | | |
| 1"x2" | | | | | | |
| 2"x2" | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

TABLE 2: METAL BOTTOM PIN PACKAGES WITH SIDEWALLS

| | A. DELID/RESEAL | | B. DELID/REPACKAGE | | C. SCRAP/NO DELID | |
|---|---|---|---|---|---|---|
| Approximate Size | Welded (Qty/Mo) | Soldered (Qty/Mo) | Welded (Qty/Mo) | Soldered (Qty/Mo) | Welded (Qty/Mo) | Soldered (Qty/Mo) |
| 3/4"x3/4" | | | | | | |
| 1"x1" | | | | | | |
| 1"x2" | | | | | | |
| 2"x2" | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

TABLE 3: METAL BOTTOM PIN PACKAGES WITHOUT SIDEWALLS

| Approximate Size | A. DELID/RESEAL Welded (Qty/Mo) | A. DELID/RESEAL Soldered (Qty/Mo) | B. DELID/REPACKAGE Welded (Qty/Mo) | B. DELID/REPACKAGE Soldered (Qty/Mo) | C. SCRAP/NO DELID Welded (Qty/Mo) | C. SCRAP/NO DELID Soldered (Qty/Mo) |
|---|---|---|---|---|---|---|
| 3/4"x3/4" | | | | | | |
| 1"x1" | | | | | | |
| 1"x2" | | | | | | |
| 2"x2" | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

TABLE 4: CERAMIC PLANAR LEAD FLATPACKS

| Approximate Size | A. DELID/RESEAL Welded (Qty/Mo) | A. DELID/RESEAL Soldered (Qty/Mo) | B. DELID/REPACKAGE Welded (Qty/Mo) | B. DELID/REPACKAGE Soldered (Qty/Mo) | C. SCRAP/NO DELID Welded (Qty/Mo) | C. SCRAP/NO DELID Soldered (Qty/Mo) |
|---|---|---|---|---|---|---|
| 3/4"x3/4" | | | | | | |
| 1"x1" | | | | | | |
| 1"x2" | | | | | | |
| 2"x2" | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

TABLE 5: OTHER PACKAGE TYPES

| APPROXIMATE SIZE | PACKAGE TYPE (I-IV) | A. DELID/RESEAL WELDED (Qty/Mo) | A. DELID/RESEAL SOLDERED (Qty/Mo) | B. DELID/REPACKAGE WELDED (Qty/Mo) | B. DELID/REPACKAGE SOLDERED (Qty/Mo) | C. SCRAP/NO. DELID WELDED (Qty/Mo) | C. SCRAP/NO. DELID SOLDERED (Qty/Mo) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

## DELIDDING

This section deals only with equipment and methods you use in delidding operations that (may) allow subsequent resealing.

1). Please rank the methods you use, starting with the most common as Method #1. If several types of equipment are utilized in a single delid process (e.g. belt sander and knife blade), show them as equal in rank. These rankings will be referred to within this "Delidding" section and in a later "Resealing" section.

| Method # | Equipment | Method # | Equipment |
|---|---|---|---|
| ________ | Belt Sander | ________ | End Mill |
| ________ | Rotary Sander | ________ | Knife Balde |
| ________ | Manual Lapping Table | ________ | Soldering Iron |
| ________ | Planetary Lapper | ________ | Hot Plate |
| ________ | Table or Radial Saw | ________ | Other ________ |
| ________ | Surface Grinder | ________ | Other ________ |
| ________ | Grinding Wheel (edge) | ________ | Other ________ |

2). Time required for delidding?

Method #1 ________ minutes/pkg.

Method #2 ________ minutes/pkg.

Method #3 ________ minutes/pkg.

3). Time required to dress flange prior to resealing?

Method #1 ________ minutes/pkg.

Method #2 ________ minutes/pkg.

Method #3 ________ minutes/pkg.

4). For the three top ranked methods used (see previous page), indicate the maximum size package delidded for each package type and for which sealing methods the delidding technique is used.

METHOD #1

| PACKAGE TYPE | MAX. SIZE DELIDDED | SEAL METHOD(s) | | |
|---|---|---|---|---|
| | | WELD | SOLDER | OTHER |
| Metal planar lead | | | | |
| Metal Bottom-pin with sidewalls | | | | |
| Metal Bottom-pin without sidewalls | | | | |
| Ceramic planar lead | | | | |
| Other | | | | |

METHOD #2

| PACKAGE TYPE | MAX. SIZE DELIDDED | SEAL METHOD(s) | | |
|---|---|---|---|---|
| | | WELD | SOLDER | OTHER |
| Metal planar lead | | | | |
| Metal Bottom-pin with sidewalls | | | | |
| Metal Bottom-pin without sidewalls | | | | |
| Ceramic planar lead | | | | |
| Other | | | | |

METHOD #3

| PACKAGE TYPE | MAX. SIZE DELIDDED | SEAL METHOD(s) | | |
|---|---|---|---|---|
| | | WELD | SOLDER | OTHER |
| Metal planar lead | | | | |
| Metal Bottom-pin with sidewalls | | | | |
| Metal Bottom-pin without sidewalls | | | | |
| Ceramic planar lead | | | | |
| Other | | | | |

## RESEAL

1). Please mention any special considerations or problems with resealing compared to original sealing, e.g. change of weld parameter setting, difficulty in dressing flange, or higher soldering temperatures. (Method numbers are taken from page 7.)

Method #1 ______________________________

______________________________

Method #2 ______________________________

______________________________

Method #3 ______________________________

______________________________

2). What percentage of packages pass fine and gross leak test after each sealing operation?

| | Original | 1st Reseal | 2nd Reseal | 3rd Reseal | 4th or more |
|---|---|---|---|---|---|
| Method #1 | % | % | % | % | % |
| Method #2 | % | % | % | % | % |
| Method #3 | % | % | % | % | % |

3). How many times do you think production packages could be delidded and resealed?

Method #1 ______________

Method #2 ______________

Method #3 ______________

## RELIABILITY

1). Do you screen production hybrids per requirements in MIL-STD-883, Method 5008?

☐ Yes ☐ No, explain ______________________________

______________________________

2). What percentage of hybrids are PIND tested? ________ %.

3). Do you PIND test per MIL-STD-883, Method 2020? ☐ Yes ☐ No

4). What percentage of hybrids are thermally shocked? ________ %.

5). At what condition do you typically thermal shock? (MIL-STD-883, Method 1011.2).

☐ A (-0 to +100°C) ☐ B (-55 to +125°C) ☐ C (-65 to +150°C)

6). Are resealed packages subjected to the same screening tests as original seal packages?

☐ Yes ☐ No, explain ______________________________

______________________________

7). Are resealed packages subject to the same minimum acceptability requirements as original seal packages?

☐ Yes ☐ No, explain ______________________________

______________________________

8). Do resealed packages exhibit yields comparable to original seal packages at each of the above tests?

☐ Yes ☐ No, explain ______________________________

______________________________

## COST SAVINGS

1). If delidding/resealing were allowable by military specifications, what annual cost savings could you realize ($/yr.)?

☐ <$10K ☐ $10-50K ☐ $50-100K ☐ $100K-500K ☐ >$500K

2). At what individual hybrid cost level do you see delidding/resealing becoming practical ($/hybrid)?

☐ < $50 ☐ $50-100 ☐ $100-200 ☐ > $200

3). If already delidding/resealing production packages, please check the annual cost savings achieved ($/yr.).

Method #1 ☐ <$10K ☐ $10-50K ☐ $50-100K ☐ $100-500K ☐ >$500K

Method #2 ☐ <$10K ☐ $10-50K ☐ $50-100K ☐ $100-500K ☐ >$500K

Method #3 ☐ <$10K ☐ $10-50K ☐ $50-100K ☐ $100-500K ☐ >$500K

4). Do you feel delidding/resealing is applicable to packages returned from the field?

☐ Yes ☐ No ☐ Maybe ______________________________

______________________________

5). If so, what additional annual cost savings could be achieved ($/yr.)?

☐ <$5K ☐ $5-10K ☐ $10-50K ☐ >$50K

6). What cost savings would you be able to realize ($/yr.) if a cost-effective method were made available to you for delidding and resealing your most common package configuration, and military specifications allowed two such delid/reseal operations?

☐ < $10K ☐ $10-50K ☐ $50-100K ☐ $100-500K ☐ >$500K

7). What equipment and techniques would you recommend for delidding and resealing the typical package configurations used in the military hybrids industry? (Briefly describe.) ______________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

8). What other significant delid/reseal work do you know of, at yours or another company, that should be included in this survey? (briefly describe)

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

THANK YOU

FOR

YOUR

PROMPT

COOPERATION!

# Appendix B.

## Qualification Test Data

## QUALIFICATION TEST DATA

### Vendor A

| PACKAGE NUMBER | FINE & GROSS | PIND | ELECTRICAL | DELID | VISUAL EXAM | ELECTRICAL | RESEAL | FINE & GROSS | PIND | ELECTRICAL | STAB. BAKE | FINE & GROSS | TEMP. CYCLE | FINE & GROSS | THERMAL SHOCK | FINE & GROSS | CENTRIFUGE | FINE & GROSS | MECH. SHOCK | FINE & GROSS | PIND | ELECTRICAL | MOISTURE RESIS. | CORROSION RESIS. | FINE & GROSS | PIND | ELECTRICAL | VISUAL EXAM | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25AC | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 25AD | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 25AP | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 25BB | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | F | P | - | - | - | - | - | P | * |
| 25BC | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 25BD | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 25BE | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | (control) |
| 25BF | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 25BH | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 25BJ | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 25BK | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 26BE | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 26BG | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 26BH | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 26BJ | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 26BK | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 26BM | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | (control) |
| 26BN | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | (control) |
| 26BR | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | (control) |
| 26BS | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 26BT | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 26BU | P | P | P | P | P | P | P | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | ** |
| 26BW | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 26BY | P | F | P | P | P | P | P | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | ** |
| 26CH | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | (control) |
| 27AA | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 27AB | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | (control) |
| 27AC | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 27AD | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |

* Failed subsequent PIND test.
** Passed subsequent PIND test.

P = Passed
F = Failed

## QUALIFICATION TEST DATA (cont.)

### Vendor A

| PACKAGE NUMBER | FINE & GROSS | PIND | ELECTRICAL | DELID | VISUAL EXAM | ELECTRICAL | RESEAL | FINE & GROSS | PIND | ELECTRICAL | STAB.BAKE | FINE & GROSS | TEMP. CYCLE | FINE & GROSS | THERMAL SHOCK | FINE & GROSS | CENTRIFUGE | FINE & GROSS | MECH. SHOCK | FINE & GROSS | PIND | ELECTRICAL | MOISTURE RESIS. | CORROSION RESIS. | FINE & GROSS | PIND | ELECTRICAL | VISUAL EXAM | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27AE | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 27AF | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | (control) |
| 27AH | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | (control) |
| 27AK | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 27AL | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 27AM | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 27AN | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | (control) |
| 27AP | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 27AR | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | F | P | - | - | - | - | - | P | (control)** |
| 27AS | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 27AT | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 27AU | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 27AV | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 27AW | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | (control) |
| 27AY | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 27AZ | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |

* Failed subsequent PIND test.
** Passed subsequent PIND test.

P = Passed
F = Failed

## QUALIFICATION TEST DATA

### Vendor B

| PACKAGE NUMBER | FINE & GROSS | PIND | ELECTRICAL | DELID | VISUAL EXAM | ELECTRICAL | RESEAL | FINE & GROSS | PIND | ELECTRICAL | STAB. BAKE | FINE & GROSS | TEMP. CYCLE | FINE & GROSS | THERMAL SHOCK | FINE & GROSS | CENTRIFUGE | FINE & GROSS | MECH. SHOCK | FINE & GROSS | PIND | ELECTRICAL | MOISTURE RESIS. | CORROSION RESIS. | FINE & GROSS | PIND | ELECTRICAL | VISUAL EXAM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26AA | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P |
| 26AB | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AC | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AD | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AE | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P |
| 26AG | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AH | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AK | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AL | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AP | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AR | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 26AT | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AU | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P |
| 26AW | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P |
| 26AX | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26AZ | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P |
| 26CA | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P |
| 26CD | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26CE | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26CK | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26CL | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P |
| 26CM | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P |
| 26CP | P | P | P | P | P | P | P | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P * |
| 26CR | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P |
| 26DA | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |
| 26DC | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P |
| 26DE | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P |
| 26DF | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P |
| 26DG | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P |
| 26DJ | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P |

* Failed subsequent PIND test.

P = Passed
F = Failed

## QUALIFICATION TEST DATA (cont.)

### Vendor B

| PACKAGE NUMBER | FINE & GROSS | PIND | ELECTRICAL | DELID | VISUAL EXAM | ELECTRICAL | RESEAL | FINE & GROSS | PIND | ELECTRICAL | STAB. BAKE | FINE & GROSS | TEMP. CYCLE | FINE & GROSS | THERMAL SHOCK | FINE & GROSS | CENTRIFUGE | FINE & GROSS | MECH. SHOCK | FINE & GROSS | PIND | ELECTRICAL | MOISTURE RESIS. | CORROSION RESIS. | FINE & GROSS | PIND | ELECTRICAL | VISUAL EXAM | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26DL | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 26DM | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 26DS | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | F | P | - | - | - | - | - | P | * |
| 26DU | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 26DV | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 26DW | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 26DX | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 28DF | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |
| 28EN | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 28EW | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 28EZ | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | P | |
| 28FD | P | P | P | - | - | - | - | - | - | - | P | P | P | P | P | P | P | P | P | P | P | P | P | - | P | P | P | P | |
| 28FG | P | F | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | - | - | - | - | - | P | |

* Failed subsequent PIND test.

P = Passed
F = Failed

# APPENDIX C. PROCESS SPECIFICATION

## DELIDDING WELDED HYBRID PACKAGES

1. SCOPE

1.1 This specification describes removing the cover from a weld sealed butterfly or bathtub package.

1.2 This specification applies only to the equipment described below, as manufactured at the time of this report's release (5/82). Future equipment modifications may allow or require process changes.

2. REQUIREMENTS

2.1 Equipment. This process shall be performed on a Sharp Precision (1640 Uppingham Drive, Thousand Oaks, CA 91360) Model SP112 Hybrid Package Cover Remover. The delidding machine shall be equipped with a 280 tooth, high speed tool steel saw blade approximately 5 inches in diameter and 0.055 inch wide; the teeth shall have a $10^{\circ}$ rake angle. The blade shall be used at 75 $\pm$ 5 revolutions per minute (rpm). The machine shall have a table feed rate of 6 $\pm$ 2 seconds per inch. This machine requires 10 amps of 115 volt electricity, and 75-110 pounds per square inch gauge (psig) compressed air or nitrogen.

2.2 Tools. A microscope, precision knife (e.g. X-acto knife), and static grounding strap are required.

2.3 Safety. The delidding machine contains a sharp saw blade which will cut objects in it's path. Keep hands, hair, and loose clothing and jewelry out of machine when machine is operating, especially when cover is raised. This is to prevent anything from becoming caught up in the moving parts of the machine, and to prevent electrical shock. Also, exercise caution when using knife in order to prevent bodily injury.

2.4 Handling. Care shall be exercised at all times to avoid damaging the package and substrate circuitry. This is especially true for process steps that occur after the lid has been removed. A static grounding strap shall be worn whenever handling packages containing functional circuitry.

3. OPERATIONS

3.1 Set up. The delidding machine shall be set up prior to use as follows:

(a) Clamp pressure shall be set to 10-15 pounds per square inch gauge (psig). [Adjust the pressure by rotating the small silver knob next to the dial face until the desired pressure is achieved. It is necessary for the machine cover to be raised in order to check and adjust the pressure. This pressure is for packages approximately 1-2 inches on a side; larger (smaller) packages may require more (less) pressure.]

(b) Cut depth shall be set equal to the thickness of the lid in the weld region, not to exceed 0.010 inch per cutting pass. [Adjust the cut depth by rotating the large black CUT DEPTH knob on top of the machine until the line on the knob is aligned with the desired depth.]

(b) Cut width shall be set wider than the weld, but not exceeding 0.010 inch less than the wall thickness; no more than 0.055 inch may be cut in a single pass. [Adjust the cut width by rotating the small black CUT WIDTH knob until the desired cut width is indicated.]

(c) Cut length shall be set to match the length of the package side being cut, not to exceed 3 inches. [Rotate the small black PACKAGE SIZE knob to set the length of cut. This can be done by aligning the line on the knob with the appropriate setting on the dial faceplate, if the package size is known. If the package size is not known, or as an acceptable alternative even if the size is known, position the red mark on the clamp bar over the center of the package ($\pm$ 0.050 inch).]

(d) The package clamp bar shall be adjusted to provide 0.030 $\pm$ 0.010 inch clearance over the package body. [This adjustment is made by rotating the screw on the clamp bar assembly clockwise (counter clockwise) to raise (lower) the clamp the necessary distance. The machine cover must be raised to make this adjustment.]

Example 1. For a 1 inch by 2 inch package with 0.040 inch thick walls and 0.020 inch wide welds and a total package height of 0.150 inch, and lids 0.005 inch thick at the edge:

(a) Set cut width to 0.030 inch.

(b) Set cut depth to 0.005 inch.

(c) Set cut length to 1 inch or 2 inch.

(d) Set clamp height for about 0.030 inch clearance.

Example 2. For a bathtub package with the same dimensions, and package leads on 0.100 inch centers:

(a) - (c) Same as above.

(d) If clamp bar has slots on 0.100 inch centers, position the clamp so that the package leads fit into the slots and the clamp contacts only the body of the package. Be careful not to damage the package leads.

Example 3. For a package with same dimensions, except the leads do not fit into the slots in the clamp, or if clamp is not slotted:

(a) - (c) Same as above.

(d) An adaptor fixture must be utilized which has been machined to provide clearance for all of the leads (and standoffs, if any); the adaptor must be thick enough to prevent the leads from protruding even a slight amount. Place the adaptor over the package leads, and adjust the clamp height to provide clearance over the package/adaptor combimation.

3.2 Removing the lid. Remove the lid as follows:

(a) Momentarily depress the red POWER button; it will light up and the saw blade drive motor will start.

(b) Place the package or package/adaptor combination (herefater, simply the package) face down on the machine's slide table.

(c) Slide the package into the reference corner, i.e. against both the back stop and the front stop.

(d) While holding the package in the reference corner, momentarily depress the white CLAMP button; the light will come on and the clamp will come down and hold the package in place.

(e) Press the green START button down and hold it down until the slide table begins to move (approximately 1/2 second); the light will come on and the vacuum motor will start.

(f) The table will automatically return when the cut is finished; the green light will go out.

(g) Depress the CLAMP button; the clamp will raise and the light will go out.

(h) Rotate the package $180^{o}$ in order to cut the opposite side of the package (the other side of the same length)

(i) Clamp the package in the reference corner again.

(j) Start the table again, machining the second side of the package.

(k) When the second cut is finished, unclamp the package and rotate it $90^{o}$ in order to cut one of the two remaining sides.

(l) If the remaining two sides are not the same length as the first two sides, adjust the PACKAGE SIZE knob as appropriate; if these sides are the same (i.e. the package is square), proceed directly to (m).

(m) Clamp the package in the reference corner.

(n) Machine the third side.

(o) Unclamp the package and rotate it $180^{o}$.

(p) Clamp the package in the reference corner.

(q) Machine the fourth side.

(r) Unclamp the package.

(s) The lid should fall freely out of the package when the package is picked up and tapped lightly on the table.

(t) Proceed to 3.3, unless the lid remained in place, in which case proceed to 3.2.2.

3.2.1 EMERGENCY PROCEDURES. If the machine malfunctions, or if it is desired to stop the machine during an operation, the following procedures apply:

(a) TO COMPLETELY STOP MACHINE: Depress red POWER button; the light will go off, all motors will stop, all lights will go out, and the clamp will raise. Removing the power cord from the wall or buss bar receptacle will also stop the machine, as will dropping the input pressure below approximately 60 psig (e.g. disconnect air supply line).

(b) TO STOP TABLE DURING CUT: Stopping the machine as in (a) is effective, but excessive. Pressing the CLAMP button will cause that light to go out, the clamp to raise, and the table to return; the START light will also go out and the vacuum motor will stop. The main saw drive motor continues running.

(c) TO RAISE CLAMP WHEN TABLE IS STOPPED: Press white CLAMP button; the light will go out and the clamp will raise. This procedure is typically used when the package has been improperly positioned under the clamp (e.g. package crooked, or wrong side under clamp).

3.2.2 Special proceudres for removing the lid. If the lid remains attached to the package after the package has been tapped lightly several times on the table, one or more of the following may apply; look at the package closely to determine the extent of the cut (a microscope may be necessary). These observations assume the lid and/or package are gold plated; if no gold is present, the task of determining the extent of cutting is more difficult.

(a) Machined area looks completely silver. If the machined region looks completely silver, the cut is either too shallow or too deep. If it is too deep, the lid should have fallen off; prying at the edge of the remaining lid will free the lid (it is recommended to do this with the lid facing down, so it falls away from the package). If the cut is too shallow, the depth of the cut may be visibly insufficient (when viewed at an angle); the interface between the lid and seal flange will not be visible. Increase the depth of cut by 0.0005 inch (1/2 mil) and repeat the four cuts; repeat this until the necessary depth is reached. It is possible in unusual situations for the cut to be too deep at one end and too shallow on the other end, and look completely silver, also. Depending on the condition of the other package sides, a choice will have to be made either to cut deeper in order to completely penetrate the lid, or to pry the lid off and dress the flange after delidding.

(b) Machined area shows silver and gold. The cut is almost the correct depth; the lid has been thinned enough for parts of it to be removed by the blade (the exposed gold may show evidence of the thinned lid fragments being scraped away). Using a microscope, it will be possible to determine if the silver is lid or seal flange by examining the gold/silver transition region. If there is a visible step from the silver down to the gold, part of the lid still remains and the cut needs to be deeper. If there is a smooth transition from gold to silver, the cut is probably starting into the seal flange. No gold will be visible at any depth in the weld region, since the gold alloyed into the weldment. If the cut is exactly the right depth, the machined area will appear silver in the weld region, and the gold on the original seal flange will be visible on the portion of the cut closest to the package center. If the cut appears to be of sufficient depth all around, lift the edge of the lid using a knife blade; hold the package with the lid facing down to allow the lid to fall away from the package. The lid should pry free easily if the cut is indeed adequate everywhere; if the lid lifts up but is held in a few areas, lift the lid up and bend it back and forth in order to fracture it in the attached region. Any regions where the lid was not completely machined through may require deburring and/or dressing with a sharp knife under a microscope.

(c) Weld remains in corners. If the package corner has a large enough radius, the saw will miss the inner portion of the weld since the blade cuts a straight path of limited width. In this case, position the package against the 45° slanted edge of the front package stop in the reference corner. Then slide the package until it hits the backstop, also. Rotate the PACKAGE SIZE knob until it points to the "C" position, indicating a corner cut is being made. Clamp the package and machine off one corner of the package; repeat for the other corners. It may be necessary to increase the width of cut in order to remove the entire weld; if this is adjusted, remember to reset it before continuing to the next package. The lid should now fall off.

(d) Weld remains along side of package. This typically happens as a result of touch up welds making the weld region wider. If only one side, or two opposite sides, have this condition, increase the cut width enough to remove the weld, even if it extends the whole wall thickness. Machine the side(s). Do not attempt any further machining of adjacent package sides, as the lid may be forced into the package, destroying the reference plane and possibly smashing the enlcosed circuitry. If all four sides have extra wide welds, do not attempt further cuts; submit the package to the process engineer for special attention.

(e) Unusual problems or conditions. Submit the package to the process engineer for special attention.

3.3 After lid has been removed. After the lid has been removed from the package, examine the seal flange under a microscope for burrs, loose lid fragments, or imperfections which may interfere with resealing. Dress the flange as necessary using a sharp knife to reduce irregularities to less than 0.002 inch. If the remaining weld bead forms a feather edge along the outside edge of the package, dress it off with the knife. Blow the package off with dry, filtered nitrogen to remove any particles. Place the delidded package in an appropriate carrier.

3.4 Troubleshooting. If the equipment fails to operate at all, make sure that the machine is getting adequate electricity and air pressure; there are built-in interlocks to prevent operation if these are not present. If other equipment problems arise, contact the process engineer or appropriate technician.

3.4.1 Steps in seal flange after cutting. A particular problem that can occur is for the saw cuts to be too deep with respect to the seal flange, or to be a different depth than the adjacent cut. If the cut is too deep all the way around the package, the cut depth setting was simply too deep. If the cut is too deep in the middle of a side, the package may be warped and/or the package may have been distorted during clamping; the latter condition may be a result of excessive clamping pressure, defective package, or the lid caved in because adjacent cuts were too wide. If the cut is too deep in the corner, the same causes apply. If the cut depth does not match that of the adjacent cut, particularly if there is a pattern to the irregularities (e.g. the end of the package cut first is always cut deeper than the trailing end of the package), then the planarity of the table needs to be adjusted; refer to the owner's manual. If this mismatch only occurs in on or two corners, check the top of the package for burrs or bumps which may have been keeping the package from being clamped perfectly flat against the table. Steps in the seal flange greater than 0.002 inch high should be dressed with a sharp knife; the intent is to dress the abrupt step down to a smooth ramp or to at least remove the sharp corner (the corner causes problems resealing).

3.5 Resealing. After circuit repair, test, inspection, and other necessary operations have been completed, the package shall be cleaned and welded in the same manner as a package being sealed for the first time. This includes using a new lid, and all the standard welding parameters.

DISTRIBUTION:

| | No. of Copies |
|---|---|
| Defense Documentation Center<br>Cameron Station<br>Alexandria, VA 22314 | 2 |
| Director<br>Army Materials and Mechanics Research Center<br>ATTN: DRXMR-PT<br>Watertown, MA 02172 | 2 |
| Director<br>U.S. Army Industrial Base Engineering Activity<br>ATTN: DRXIB-MT<br>Rock Island Arsenal<br>Rock Island, IL 61201 | 2 |
| Commander<br>U.S. Army Materiel Development and Readiness Command<br>ATTN: DRCMT<br>5001 Eisenhower Avenue<br>Alexandria, VA 22333 | 1 |
| Commander<br>U.S. Army Tank-Automotive R&D Command<br>ATTN: DRDTA-R<br>Warren, MI 48090 | 1 |
| Commander<br>Frankford Arsenal<br>ATTN: SARFA-MTT<br>Bridge and Tacony Streets<br>Philadelphia, PA 19137 | 1 |
| Commander<br>Picatinny Arsenal<br>ATTN: SARPA-MT-C<br>Dover, NJ 07801 | 1 |
| Commander<br>U.S. Army Aviation Systems R&D Command<br>ATTN: DRDAV-EXT<br>12th and Spruce Streets<br>St. Louis, MO 63166 | 1 |
| Commander<br>U.S. Army Electronics R&D Command<br>ATTN: DELET-TL-IC<br>Fort Monmouth, NJ 07703 | 1 |

DISTRIBUTION:

| | No. of Copies |
|---|---|
| Commander<br>U.S. Air Force Materials Laboratory<br>ATTN: AFML/LT<br>Wright-Patterson AFB, OH 45433 | 1 |
| Commander<br>Naval Material Command (Code 042)<br>CP #5, Room 722<br>Washington, DC 20360 | 1 |

DISTRIBUTION:

Delid/Reseal MM&T Industry Demonstration Attendees (12/15/81)

R. M. Gerber
Mail Stop D8/1146
Aerospace Corporation
P.O. Box 92957
Los Angeles, CA 90009

C. W. Kuzia
Arzac Electronics
80 Cambridge Street
Burlington, MA 01803

E. W. Surette
Arzac Electronics
80 Cambridge Street
Burlington, MA 01803

Robert Bryan
Bendix Communications Division
1300 East Joppa Road
Baltimore, MD 21204

Steve Leven
Bendix Communications Division
1300 East Joppa Road
Baltimore, MD 21204

A. Frusco
ILC Data Device Corporation
105 Wilburn Place
Bohemia, NY 11716

Leo F. Garvey III
ILC Data Device Corporation
105 Wilburn Place
Bohemia, NY 11716

Albert Bauer
ITT Avionics
500 Washington Avenue
Nutley, NJ 07110

Harry Vasquez
DCA/CCTC
Defense Communications Agency
8th Street and South Courthouse Road
Arlington, VA 22204

W. J. Bcwles
Room 1934
General Electric Company
RSD
3198 Chestnut Street
Philadelphia, PA 19101

G. G. Dency
Harris Corporation G.I.S.D.
P.O. Box 94000
Melbourne, FL 32901

Rod J. Steward
Honeywell-Avionics Division
13350 U.S. Highway 19
St. Petersburg, FL 33733

Ira Custman
ILC Data Device Corporation
105 Wilburn Place
Bohemia, NY 11716

Lex E. Vinsel
Mail Stop 10-3
McDonnell Douglas
5301 Bolsa Avenue
Huntington Beach, CA 92647

Ken Beech
Mail Stop 12-24
Raytheon Corporation
Wooburn Street
Lowell, MA 01853

Alfred G. Benjamin
Raytheon Corporation
465 Center Street
Quincy, MA 02169

DISTRIBUTION:

Daniel D. Zimmerman
JHU Applied Physics Laboratory
Johns Hopkins Road
Laurel, MD 20810

Connie Gill
Martin Marietta
P.O. Box 5837
Orlando, FL 32855

Lee Petty
Martin Marietta
P.O. Box 5837
Orlando, FL 32855

Harry Hammer
1 EZ 90
1150 McBride Avenue
Little Falls, NJ 07424

Robert Mason
Solid State Equipment Corporation
1015 Virginia Drive
Ft. Washington, PA 19034

Bill Winn
Solid State Equipment Corporation
1015 Virginia Drive
Ft. Washington, PA 19034

T. Moran
Solid State Engineering Corporation
1015 Virginia Drive
Ft. Washington, PA 19034

C. Glenn Prince
Mail Stop 88
Texas Instruments
P.O. Box 226015
Dallas, TX 75222

A. J. Wallace
Department 2366
Raytheon Industrial Components
465 Center Street
Quincy, MA 02169

Jim Victor
Sharp Precision
1460 Uppingham Drive
Thousand Oaks, CA 91360

Gerald Gorman
12 B71
Singer-Kearfott
150 Totowa Road
Wayne, NJ 07470

Commander
U.S. Army Missile Command
DRSMI-RST (Austin)
Redstone Arsenal, AL 35898

Augustus H. Lane, Jr.
WR-ALC/MAIES
Robins AFB, GA 31098

William F. Boisclair
WR-ALC/MAIES
Robins AFB, GA 31098

Kent Harmison
Mail Code 963
Naval Avionics Center
6000 East 21st Street
Indianapolis, IN 46218

Don Crowe
Naval Avionics Center
6000 East 21st Street
Indianapolis, IN 46218

DISTRIBUTION:

Personal Requests for Final Report - Delid/Reseal MM&T

Dr. W. D. McKee
Code 925
Naval Ocean Systems Center
271 Catalina Boulevard
San Diego, CA 92152

John Hornby
General Dynamics
P.O. Box 2507
Pomona, CA 91766

Brian Montyro
Garrett Manufacturing Corporation
255 Atwell Drive
Rexdale, Ontario, Canada M9W 5B8

Ronald Fess
General Electric Corporation
French Road
Utica, NY 13503

Susan Williams
Mail Stop M-2
Sperry Flight Systems
Phoenix, AZ 85027

Don Hunter
Harry Diamond Laboratories
2800 Powder Mill Road
Adelphi, MD 20783

Charles Giaconia
Hughes Aircraft
P.O. Box 11337
Tuscon, AZ 85734

Charles Ray
Fairchild Space and Electronics
Germantown, MD 20767

Dallas Courtney
General Dynamics
Convair Division
P.O. Box 80846
San Diego, CA 92138

R. C. Barnwell
Hughes Aircraft
P.O. Box 11337
Emery Park Station
Tuscon, AZ 85734

George Ebel
12-B-12
Singer-Kearfott
150 Totowa Road
Wayne, NJ 07470

Frank Cheriff
Raytheon
528 Boston Post Road
Sudbury, MA 01776

Phil Creter
GTE Sylvania
99 "A" Street
Needham, MA 02194

John Morey
Analog Devices
Route 1, Industrial Park
Box 280
Wakefield, MA 02062

Don Wagner
JHU Applied Physics Laboratory
Johns Hopkins Road
Laurel, MD 20810

Bill Webster
Naval Weapons Center
Code 3318
China Lake, CA 93555

Daren Ribner
General Optronics
3005 Hadley Road
South Plainfield, NJ 07080

DISTRIBUTION:

Delid/Reseal MM&T Industry Survey Respondents

Robert B. Golightly III
Mail Code 194/7332
Aerojet Electro Systems Company
P.O. Box 296
Azusa, CA 91702

Richard Gerber
Mail Stop D8/1146
Aerospace Corporation
Box 92957
Los Angeles, CA 90009

Edward Surette
Anzac Electronics
80 Cambridge Street
Burlington, MA 01803

John Schreffler
Applied Technology
645 Almanor Avenue
Sunnyvale, CA 94086

John W. Kanz
Ball Aerospace Systems Division
1488 West 178th Street
Gardena, CA 90247

Cynthia Cannon
COMSAT Laboratories
DFC/Product Engineering
22300 Comsat Drive
Clarksburg, MD 20734

Yukiko S. Keveren
Mail Code 203
ESL, Inc.
495 Java Drive
Sunnyvale, CA 94086

James J. Davison
Mail Stop 3-64
Ford Aerospace
Ford Road
Newport Beach, CA 92660

LaVar Clegg
Department 4862, Mail Code E-33
Beckman Instruments
2500 Harbor Boulevard
Fullerton, CA 92631

Hal Greenhouse
Department 480
Bendix-Communications Division
1300 East Joppa Road
Baltimore, MD 21204

Jack H. Williams
Department 842, Mail Code MF-39
Bendix Corporation
P.O. Box 1159
Kansas City, MO 64141

Elizabeth Zimmerman
Boeing Aerospace Corporation
Box 3999
Seattle, WA 98124

Bill Stacy
Burr-Brown Research Corporation
P.O. Box 11400
Tuscon, AZ 85734

Ray Ottaway
General Dynamics
P.O. Box 2507
Pomona, CA 91766

Merrill Palmer
General Dynamics
Electronics Division
P.O. Box 81127
San Diego, CA 92318

J. Charles Gioia
MESO CSP 5-W2
General Electric Company
P.O. Box 4840
Syracuse, NY 13221

DISTRIBUTION:

David Williams
Frequency Sources
16 Maple Road
Chelmsford, MA 01824

George Erdos
Garrett Manufacturing Corporation
255 Atwell Drive
Rexdale, Ontario, Canada M9W 5B8

Robert Moore
General Electric Company
Ordnance Division
Pittsfield, MA 01201

Theodore Johnson
M.D. 263
General Electric Company
Aerospace Electronics
French Road
Utica, NY 13503

Saul Shapiro
Department 122
GTE Products
77 "A" Street
Needham Heights, MA 02194

Joe Ansel
Harry Diamond Laboratories
2800 Powder Mill Road
Adelphi, MD 20783

Steve Hinch
Engineering Manager
Hewlett-Packard
1400 Fountain Grove Parkway
Santa Rosa, CA 95404

Daniel J. Renn
Integrated Circuits, Inc.
13256 Northrup Way
Bellevue, WA 98005

A. A. McCulloch
General Electric Company
751 5th Avenue
King of Prussia, PA 19460

M. R. Stahler
M-8639
General Electric Company
Space Division
P.O. Box 8555
Philadelphia, PA 19101

W. O. Perry
Honeywell-Avionics Division
13350 U.S. Highway 19
St. Petersburg, FL 33733

Ray Delea
Hughes-Radar Systems Group
P.O. Box 92426
El Segundo, CA 90009

A. Koudounaris
Mail Code A1241
Hughes-Solid State Products
500 Superior Avenue
Newport Beach, CA 92663

Jack McDaniel
Hughes Aircraft
P.O. Box 11337
Tuscon, AZ 85734

Steve Reiss
Section 64511
ITT-Avionics
500 Washington Avenue
Nutley, NJ 07110

Richard A. Lillmars
Manager
Manufacturing/Engineering
Microelectronics
Magnavox Government and Industrial
Electronics Company
4624 Executive Boulevard
Fort Wayne, IN 46808

DISTRIBUTION:

Daniel Zimmerman
EME 16-207
JHU Applied Physics Laboratory
Johns Hopkins Road
Laurel, MD 20810

Gerritt Peddemors
Mail Code 438
Lear Siegler, Inc.
4141 Eastern Avenue, S.E.
Grand Rapids, MI 49508

C. L. Razer, Mail Stop 30
Manager, Hybrids Laboratory
Litton Guidance and Control
5500 Canoga Avenue
Woodland Hills, CA 91367

Louis J. Boccia
Department 71-33
Building 151
Lockheed Missiles and Space Co., Inc.
P.O. Box 504
Sunnyvale, CA 94086

George G. Harmon
Building 225, Room B354
National Bureau of Standards
Washington, DC 20234

Dr. Willard P. Webster
Code 3318
Naval Weapons Center
China Lake, CA 93555

Phil Eisenberg
Northrop Corporation
2301 West 120th Street
Hawthorne, CA 90250

Robert W. Ilgenfritz
Mail Code M27-6
Raytheon Missile Systems
Hartwell Road
Bedford, MA 01730

Ken W. Brown
9300, Mail Stop 189
Martin Marietta Aerospace
P.O. Box 5837
Orlando, FL 32855

Robert E. Sulouff
Microelectronic Engineering Corporation
P.O. Box 1209
Auburn, AL 36830

Charles Ansley
Micropac Industries, Inc.
905 East Walnut Street
Garland, TX 75040

Ray Allen
Mail Code 1330
Motorola G.E.D.
8201 East McDowell Road
Scottsdale, AZ 85252

Milton Stoll
Research Instrument Co., Inc.
36 Mascolo Road
South Windsor, CT 06074

Hal Goldfarb
Mail Code DF03
Rockwell International
3370 Miraloma Avenue
Anaheim, CA 92803

Charles R. Pratt
Electronic Devices Division
Rockwell International
P.O. Box 10462
Dallas, TX 75207

Robert C. Carr
Mail Code 137-153
Rockwell-Collins
P.O. Box 728
Cedar Rapids, IO 52406

DISTRIBUTION:

Alton J. Wallace
Department 2366
Raytheon Industrial Components
465 Centre Street
Quincy, MA 02169

Frank Rasmussen
Raytheon Corporation
Mountain View, CA 94042

S. A. Herman
Mail Code 1EB90
Singer-Kearfott
1150 McBride Avenue
Little Falls, NJ 07424

Duane Rhode
Mail Station M-1
Sperry Flight Systems
P.O. Box 2111
Phoenix, AZ 85036

Jim Victor
Sharp Precision
1460 Uppingham Drive
Thousand Oaks, CA 91360

Robert Ost
Sperry Gyroscope
Great Neck, NY 11020

George H. Ebel, 12-B-12
Singer-Kearfott
150 Totowa Road
Wayne, NJ 07470

Ron Chalman
Tekform Products Company
2770 Coronado
Anaheim, CA 92806

John Adolph
Teledyne Microelectronics
12964 Panama Street
Los Angeles, CA 90066

Louis A. Razzetti
Westinghouse Electric Corporation
Defense and Electronics Systems
Center
P.O. Box 746, Mail Stop V-20
Baltimore, MD 21203

Jay Tenzer
Solitron Devices
1177 Blue Heron Drive
Riviera Beach, FL 33404